ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

VOL. XL. No. 13.

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THE LARGEST SINGLE CONTRACT ever let for an open-hearth steel furnace plant was closed on Sept. 24 between the Riter-Conley Co., of Pittsburg, Pa., and the Alabama Steel and Shipbuilding Co., Ensley, Ala. The contract calls for ten 50-ton "Wellman" rolling furnaces; the general dimensions being approximately 21 ft. wide, 37 ft. 6 ins. long, with a total height above foundations of about 22 ft. The contract embraces everything complete above foundations, including steel castings, hydraulic cylinders, and all plate and structural work for casings, bindings, pedestals, etc. The work requires approximately 400 tons of steel castings alone, while the total tonnage of steel work and all is nearly 2,000 tons. The work is to be erected complete at the new steel works at Ensley, the foundations being already finished. A gas producer house and a storage bin, 18 ft. wide by 343 ft. long, both of steel construction, are also included in the contract. The work was all designed by the Wellman-Seaver Engineering Co., Cleveland, O.

A VERY LARGE ENGINE SHAFT is being constructed by the Bethlehem Iron Co., of South Bethlehem, Pa., for the Corliss Steam Engine Co., of Providence, R. I. This shaft will be 27 ft. 10 ins. long, with a maximum diameter of 37 ins., a bearing diameter of 34 ins., and a diameter of 32 ins., where the crank-disks fit on. Throughout its length is a 17½-in. hole. It is estimated that the finished shaft will weigh about 63,000 lbs. The specifications call for an elastic limit not less than 50,000 lbs. per sq. in., and an elongation of 18% in a round test piece 1x10 ins.

A NEW PLANT FOR MAKING LARGE GUNS is about to be erected by the Carnegie Steel Co., at Homestead, Pa., according to a press despatch. A plot of ground of 35 acres on the Monongahela, within half a mile of the armor-plate mill has been purchased, and four buildings will be erected with a capacity for employing 2,000 hands. The new plant will probably contain only turning and other finishing machinery, as the open-hearth plant and hydraulic forging machinery now at the Homestead works are well adapted to produce gun forgings.

THE NEW 12-IN. GUN FOR THE NAVY is intended to take the place of the old 13-in. gun. With this object in view, it has been increased in weight from 46 to 52 tons; but the 13-in. weighed 61 tons. The new 12-in. is designed to use a powder charge giving a velocity of 3,000 ft. per second to its projectile, says the Washington correspondent of the New York "Sun," as compared with 2,000 ft. for the old 13-in. gun.

A 12-IN. KRUPP PROCESS ARMOR-PLATE, made by the Carnegie Co., was tested at Indian Head on Sept. 12. A 6-in. plate had previously been tested by a 6-in. shell with surprising results, and the government demanded the thicker plate now tried. The new plate was slightly under 12 ins. in thickness, and was substantially bolted to brates and backed by about 7 ft. of wood. The gun used was a new navy 12-in. gun, at 300 ft. range. Three shots were fired with armor-piercing projectiles. The first had behind it 380 lbs. of powder, imparting a velocity of 1,833 ft. per second; this projectile penetrated 8½ ins. and remained imbedded, with signs of being badly distorted at the point; but there were no radial or other cracks in the plate. The second shot had 417 lbs. of powder, giving a velocity of 2,022 ft. per second; as expected, this shot passed clear through the plate and backing, but what was found of the shell was badly broken and distorted. With the third shot only 370 lbs. of powder were used, with a velocity of 1,720 ft. per second; this shell penetrated about 5 ins. and stuck in the armor. But at the end there were no opening cracks in the plate, such as would be expected under so severe a test. The experts estimated that this plate had as much resisting power as a 13½-in. plate treated by the ordinary Harvey process. The test was so satisfactory that the Krupp process will probably be used for the armor on the new warships now contracted for. The maximum thickness of armor will probably be 15 ins., instead of 18 ins.

A 35.2-KNOT SPEED, for the torpedo-boat destroyer "Hai Lung," is claimed by the "Kolnische Zeitung." This boat was built at Elbing, Germany, for the Chinese government by the Schichau Co., and the trial runs were made in the open sea over a 19-knot course, with a fresh wind and considerable sea. The boat traversed this course several times, the average time being 32 m. 28 s.; or the equivalent of a speed of 68 kilometers, 35.2 knots, or 40.8 statute miles. This is claimed to be in excess of any speed heretofore made on the water, surpassing that of the "Turbinia."

THE SPANISH ARMORED CRUISER "INFANTA Maria Teresa," sunk at Santiago on July 3, has been finally raised and towed into the harbor of Guantanamo, Cuba. This ship was built at Bilboa in 1890, and is a twin-screw steel vessel, 364 ft. long over all; 65 ft. 2 ins. beam; 21 ft. 6 ins. mean draft; with a displacement of 6,890 tons. She has two sets of vertical, triple-expansion engines, and under natural draft these engines developed 9,500 I. HP., giving a speed of 18½ knots; under forced draft the power developed was 13,700 I. HP., with 20.2 knots speed. She will carry 1,050 tons of coal, giving her a steaming radius of 9,700 miles at 10 knots. Her water-line steel armor belt is 5½ ft. deep, 315 ft. long, and from 10 to 12 ins. thick. Her two turrets have 9-in. armor; the conning tower is 12 ins. thick, and the protective deck is from 2 to 3 ins. thick. Each turret contains one 11-in. Hontoria gun; and she had ten 5.5-in. Hontoria rapid-fire guns, eight 6-pdr. and ten 1-pdr. rapid-fire guns, with eight Nordenfeldt and two Maxim machine guns, and eight torpedo tubes. Her complement of officers and men was 484. The work of raising the "Infanta Maria Teresa" was performed by the Merritt-Chapman Wrecking Co., under the direction of Naval Constructor Hobson.

THE FOUR COAST DEFENCE MONITORS for which bids will be received this week, are already named the "Arkansas," "Connecticut," "Florida" and "Wyoming." These monitors are limited in cost to $1,500,000 each, and the general plan includes a single, balanced Hichborn turret on the center-line forward, armed with two high-power 12-in. rifles for smokeless powder, and four 4-in. rapid-fire guns will be mounted on a raised superstructure aft of the turret. There will also be a secondary battery of three 6-pdr. and four 1-pdr, automatic rifles. The length of the monitor on the load water line will be 225 ft.; extreme beam on the water line, 50 ft.; mean draft at normal displacement, 12 ft. 2 ins.; normal displacement, about 2,700 tons; total coal capacity, loose stowage, 200 tons. The hull will be unsheathed steel, with double-bottom and water-tight subdivision; there will be one military mast. The side armor belt will have a maximum thickness of 11 ins., tapering to 5 ins., with a depth of 5 ft. The barbette will be 10 ins. thick, and the turret will have 10-in. inclined front plates at an angle of 42°, with side plates 9 ins. thick. Two vertical, triple-expansion engines, with 17.26¼ and 40-in. cylinders and 24-in. stroke, will drive twin screws. Four water-tube boilers will furnish steam at a working pressure of 250 lbs. The speed called for is only 12 knots.

SMOKELESS POWDER for the navy is to be made in a government factory now being established within two miles of the proving grounds at Indian Head. The factory is being built under an appropriation of $97,000 made by the last Congress, and the work of construction will be under the charge of Lieutenant Bernadou, U. S. N., an expert in the development of smokeless powder. The plans call for a plant capable of making from 3,000 to 5,000 lbs. of powder per day, and to this must be added the Newport government plant, with a capacity of 1,000 lbs. per day. The Duponts and the California Powder Co. are now each under contract to furnish 500,000 lbs. of smokeless powder.

U. S. NAVAL ESTIMATES for the coming fiscal year aggregate about $20,000,000 in four bureaus alone. The Ordnance Bureau asks for $6,475,358, to meet ordinary expenses and the amount necessary to pay for guns and armor on ships under construction or contracted for. An additional sum will be required for the torpedo boats and destroyers soon to be contracted for. The Bureau of Construction and Repair wants $6,000,000 for vessels building, and $3,500,000 to make necessary repairs on ships in service. The Bureau of Steam Engineering asks for $1,000,000 for repairs to the machinery of ships. The Bureau of Yards and Docks wants $1,500,000 for a large dry dock at the Norfolk Navy Yard; $612,000 for the Brooklyn Navy Yard; $306,000 for Portsmouth; $367,000 for Boston; $755,000 for League Island; $2,000,000 in total for Norfolk; $25,000 for New London; $148,000 for Port Royal; $112,000 for Key West; $871,000 for Mare Island, and $53,000 for Puget Sound.

THE POST-GRADUATE COURSE IN NAVAL ARCHITECTURE, commenced at Annapolis last year, under Naval Constructor Hobson, is abandoned by order of the Secretary of the Navy, on the recommendation of Chief Constructor Hichborn. The latter does not deem it practicable for the student to receive from one instructor the advantages or attention necessary for a thorough training. After examining the leading technical schools of the country, he recommends that the cadets selected each year for this post-graduate course be sent to the Massachusetts Institute of Technology, at Boston. This eminently sensible plan has been approved and eight cadets have been ordered to report there on Oct. 1 for a course covering three years. This includes practical instruction during the summer at shipyards and naval stations. The present class will be the largest ever instructed in naval architecture at one time. The practice, for the last 15 years, has been to select the three cadets graduating with highest honors each; and, until recently, these were sent for two years to leading technical schools in England and France. For the first five years the American cadets were educated at the Royal School at Greenwich; but this privilege was later refused by the British government. It will cost the government about $800 per year for the education of each cadet, exclusive of their pay.

TORPEDO BOAT AND DESTROYER AWARDS were made as follows on Sept. 23, by the Navy Department:

No. boats.	Contractor.	Class.	Plan.	Price for each.
3	Neafie & Leavey, Philadelphia.....D.*		D.§	$283,000
2	Trigg Co., Richmond, Va.	"	"	260,000
2	Harlan & Hollingsworth, Wilmgton	"	B.‡	291,000
2	F. C. Wellington, Weymouth, Mass.	"	"	281,000
3	Union Iron Works, San Francisco.	"	D.§	285,000
1	Gas Eng.& Power Co.,MorrisH'gths	"	...	Not stld.
3	Maryland Steel Co., Baltimore, Md.	"	B.‡	280,000
1	Lewis Nixon, Elizabethport, N.J...T.†		"	161,000
2	Bath Iron Works, Bath, Me.....	"	"	161,000
2	Lawley & Sons, Boston, Mass.....	"	D.§	159,400
2	Lewis Nixon, Elizabethport, N.J...	"	B.‡	165,000
3	Trigg Co., Richmond, Va.....	"	D.§	129,750
1	Columbia Iron Works, Baltimore.	"	"	168,000
1	Gas Eng.& Power Co.,MorrisH'gths	"	...	Not stld.

* Destroyers. † Torpedo boats. § Department. ‡ Bidder.

SEGMENTAL WIRE GUNS, to the number of 50, and costing $500,000, have been ordered by the War Department from the Brown Segmental Gun Co., of Reading, Pa. They include 25 5-in. and 25 6-in. guns. "The Army and Navy Journal" says that army ordnance officers protested against the contract on the ground that "there never had been a successful test of this gun." The Brown Segmental Gun Co. answers this charge by saying that a 5-in. segmental tube wire gun, 44 caliber long, was some years ago turned over to Gen. Flagler for test. Though the contract called for a maximum chamber pressure of 50,000 lbs. per sq. in., 192 rounds were fired from this gun, with 43 rounds at pressures from 50,000 to 60,000 lbs., and six rounds with pressures ranging from 60,000 to 82,850 lbs. per sq. in. The gun survived this severe treatment, though the lining tube finally yielded; and this tube was only considered good for 150 rounds at 50,000 lbs. pressure, instead of 192 shots. The company considers this a very successful and thorough test of the qualities of the wire-wound gun.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred Sept. 22 on the Wisconsin Central R. R., close to White River, a small station near Ashland, Wis. A freight train broke in two while going down grade and the rear portion ran into the forward cars, killing one man and seriously injuring another.

A CYCLONE passed over the strip of land between Lakes Ontario and Erie on Sept. 26, almost parallel to the Welland canal. In its progress a swath, about 300 ft. wide, was swept over and a branch took in a portion of Tonawanda, N. Y. Six persons were killed and 9 are reported seriously injured.

A GRAIN DUST EXPLOSION, on Sept. 23, wrecked the granary of the Eastern Distilling Co., at Bilssville, Long Island, caused the death of one man and injured four others. The granary was three stories high, built of brick and timber, with wooden partitions covered with corrugated iron. The force of the explosion blew parts of the building 100 ft. into the air, and buried part of the Long Island track with wreckage and twisted machinery, and flames spread like a flash through the steam grain conveyor connecting the granary with the docks.

THE PLANT OF THE PENCOYD IRON WORKS, PENCOYD, PA.

(With double-page plate.)

The Pencoyd Iron Works is one of the best-known of the several plants in this country which combine the design and construction of steel bridges and buildings with the manufacture of commercial steel in the form of castings, forgings, bridge steel and structural shapes of all kinds. The works were started in 1852 by Algernon and Percival Roberts, and until 1887 they manufactured puddled iron. In that year the product was changed from iron to open-hearth steel, a change which, of course, necessitated a complete modification of the plant and of the methods of handling and manipulating the metal in all of its stages of manufacture. Since first starting work as a steel plant, many improvements and extensions have been made in all departments until the works have reached their present great size and complete equipment.

Before commencing the detailed description of the plant as it now exists, however, a brief explanation of the drawings which are shown herewith and on our inset sheet will be advantageous. The works are located on the west bank of the Schuylkill River, a few miles north of the business center of the city of Philadelphia, Pa., and occupy a narrow strip of land between the tracks of the Philadelphia & Reading R. R. and the river bank. Figs. 1 and 2 show the arrangement of the shops to fit this narrow tract. The material is delivered by rail at the south end of the works, and at the north end is located the foundry building. The other mills and shops are arranged between these two in the manner shown. It will be noted that the plans of the different buildings show the location of the furnaces, roll trains, hot beds, and all the various larger stationary machinery and tools with which they are equipped. Figs. 3, 4 and 5 show the arrangement for handling the metal at the furnaces and typical sections of the mill building and bridge shop. The half-tone views of special tools and machines which comprise the remainder of the illustrations are explained by the captions underneath each. With this explanation the various drawings and other illustrations can be studied intelligently in connection with the descripton which follows.

Shortly after beginning the manufacture of steel it was foreseen that open-hearth steel would be demanded in structural work, and the Pencoyd works, escaping the difficulties which were encountered by some of their contemporaries who put in Bessemer converters, adhered exclusively to the open-hearth process for their steel product. There are now nine 30-ton furnaces in operation, each producing about 450 tons per week, and a tilting furnace of 75 tons capacity is under construction. All of these furnaces are basic lined. The general arrangements for handling the metal are shown by Fig. 3, which is a section in elevation of the open-hearth works.

The raw material, pig iron, scrap and basic additions used, are placed in boxes in the yards, and shifted on cars to the furnace floor, where they are handled by a Wellman electric charging machine The molten steel is handled over the pits in ladles supported in radial hydraulic cranes, each furnace having its own ladle crane. The ingots are stripped and delivered by electric traveling cranes and cars to the pit furnaces of the blooming mill (Fig. 1), thence being reduced by the blooming mill to blooms and billets of the various sizes required by the finishing mills.

The blooming mill is a 36-in., two-high reversing mill, driven by a pair of 40-in. × 60-in. engines geared two to one to the mill. These engines have piston valves and a Marshall reversing gear operated by a hydraulic ram. The spur gear is 7½ ins. pitch and 30 ins. face and is cut from solid steel. The tables of this mill are equipped with hydraulic manipulators, so that all the operations are directed from a central station. The mill and engine are surmounted by a 30-ton electric traveling crane, and provided with a floor carriage for changing the rolls. This mill is fed by four vertical pit furnaces of the regenerative type, fired with producer gas. The products of the blooming mill supply three finishing mills and the axle forge. The principal part of the product goes to the beam mill, which is supplied with hot blooms. All the other mills receive their charges cold.

Beam Mill.—The beam mill is placed in the line of delivery of the blooming mill and is served with three regenerative heating furnaces for restoring full working temperature to the blooms on their passage from the blooming mill. Each of these furnaces is of very large capacity, being capable of receiving about 30 tons of steel blooms and is worked continuously, being charged and drawn at the same time. The mill furnaces are served with electric charging machines (Fig. 6), receiving current from an overhead trolley and operated by two motors, one for the traveling truck, the other for the longitudinal motion of the billet. This movement being effected by frictional contact of a heavy ram on moving rollers gives a desirable working freedom to the machine. This machine is so arranged that the billets pass over it and are pushed into the furnace by the ram, and also withdrawn by the same action by tongs, the billets passing directly over the table.

The beam mill consists of two distinct mills, for roughing and for finishing. The roughing mill is a 28-in. two-high reversing mill with a single pair of rolls, and the finishing mill is a 23-in. three-high mill with two stands of rolls. A notable feature is the absence of a flywheel from the three-high mill which allows of instantaneous stoppage or reversal in the case of accidents and places the mill under full control of the operator, thus avoiding those annoying accidents which have heretofore been so common in rolling mill practice. The engines are fitted with the Marshall reversing gear, the reversing levers being controlled by a hydraulic ram. The valves are double-ported balanced slide valves. The engines are of very substantial construction and have run at a

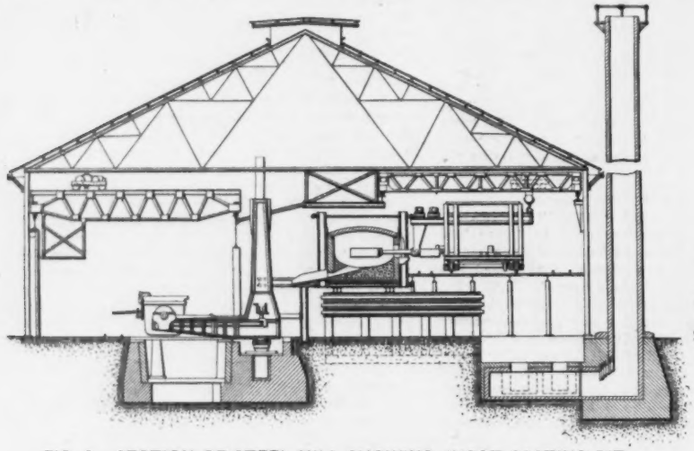


FIG. 3.—SECTION OF STEEL MILL SHOWING INGOT-CASTING PIT.

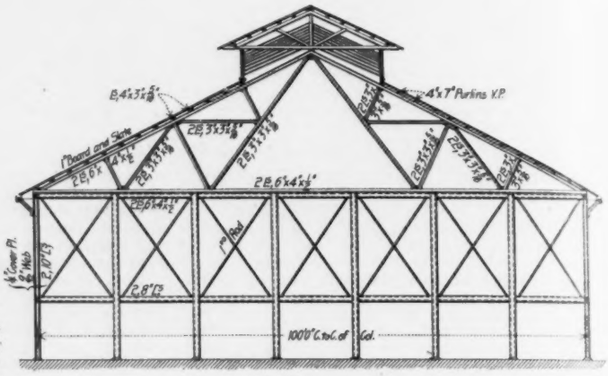


FIG. 5.—SECTION OF MILL BUILDING.

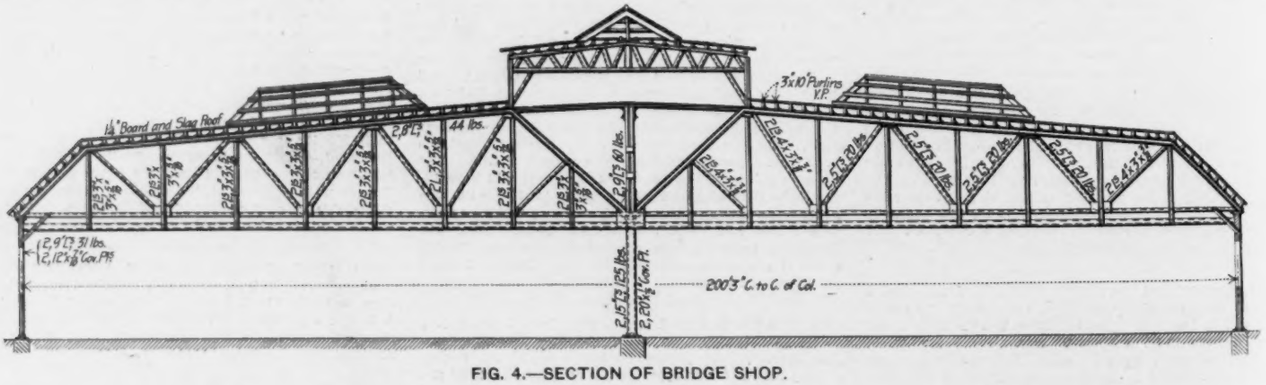


FIG. 4.—SECTION OF BRIDGE SHOP.

piston speed of 1,500 ft. per minute without difficulty.

A roll changing house is located in the line of the mill, and the whole area is covered with a 40-ton traveling crane, which lifts a complete stand of rolls and fixtures, and permits the adjustment of rolls to be made while the mill is in operation.

The roughing mill is served with reversing tables and hydraulic manipulators, while the three-high finishing mill has traveling tables which have also a lifting movement operated by a hydraulic ram which raises or lowers the end of the table next to the mill, the opposite end being hinged. These tables are each operated by a single attendant. the horizontal movements are effected electrically under the Ward-Leonard system of control. The mill handles with ease the heaviest sections of structural steel up to and including 24-in. I-beams.

Not the least advantage of having the rolling mill equipped with tables is that much higher speed can be maintained and longer lengths can be handled than is otherwise practicable. In this mill the material is delivered at a speed approximating 1,000 ft. per minute and is regularly rolled in 150-ft. lengths and can be rolled much longer. The product of the finishing mill is delivered by live rollers to the saws or at the end of the tables to a shear (Fig. 7) for cutting up small billets and similar work. The finished material is transferred to cooling beds in the usual manner and then passed through straightening machines and suitable shears for cutting to lengths. Angles and similar sections are all straightened by roller straightening machines (Fig. 8), while gag presses are used for beam straightening.

The receiving yard for finished material at the end of the mill is covered by four parallel electric traveling cranes, each of 6 tons capacity. The floor of this stock yard is fitted with tables of live rollers, electrically driven, and with devices for transverse movement of the material.

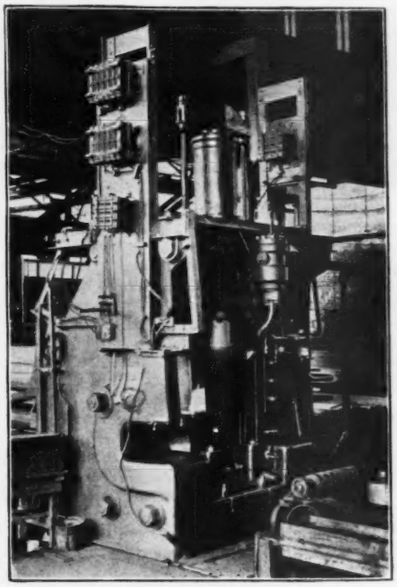


FIG. 7.—HYDRAULIC BILLET SHEARS.

poses. Three steam hammers are used for forging car axles. The steel billets for axles are delivered from the blooming mill about 6½ ins. square in the rough, and are finished at a single heat, into car axles. The axles as forged are delivered to the axle shop on the east side of the building, where they are cut, centered, turned and finished, as required. This department uses 14 lathes and turns out about 2,000 axles per week. Immediately outside this building are two drop-testing machines. In both machines the drop weighs 1,640 lbs., and the anvils upon which the axles are placed are 3 ft. between centers. The first has a maximum drop of 31 ft. and the anvil is on a solid foundation, while the second anvil weighs 17,500 lbs. and is supported on springs to conform to the specifications of the Pennsylvania R. R. Co. This fixes the inertia of the anvil and renders it independent of the foundation. It may be noted in passing that the specifications for axles are now more definite and the inspection more rigid than formerly. The chemical and physical requirements are insisted upon without much latitude for variation, the general tendency being to require a higher carbon limit and all other components lower than previously.

Steam Boiler Plant.—There are at present three principal steam boiler plants at the works. Boiler house No. 2 consists of twelve 156-HP. Babcock & Wilcox boilers; boiler house No. 3 contains four 250-HP., four 140-HP. and four 156-HP. Babcock & Wilcox boilers equipped with mechanical stokers; boiler house No. 2 is also being equipped with mechanical stokers. Bituminous coal is used throughout the works. The use of the mechanical stoker, especially when supplemented by coal and ash handling appliances, results in some economy of labor in extensive boiler plants and an abatement of smoke. An extensive series of tests run at the works indicate little economy other than that mentioned over hand firing.

Boiler houses Nos. 2 and 3 are connected by a 16-in. steam pipe and supply steam for all parts of the works, excepting the bridge department. There is a main trunk line for exhaust steam throughout the works, which collects the exhaust steam and conveys it to feed water heaters or for heating purposes in winter. The principal engines of the works, however, are supplied with condensers.

Boiler house No. 4 has one 250-HP., and two 156-HP. Babcock & Wilcox boilers. These are furnished with the chain grate stokers of the Babcock & Wilcox Co. and with the ash and coal conveyors of the Link Belt Engineering Co. Their operation is shown by the drawings Figs. 1 and 2. The coal is dumped from the cars between a pair of crushing rolls. These deliver to the conveyors which carry the coal to bins above the boilers, from which it falls to the stoker hoppers. The ashes are conveyed from ash pits to a bin over a car track and are dumped into empty cars run under the bin. This boiler plant supplies all steam used for power purposes at the bridge department,

FIG. 9.—TEN-TON ELECTRIC TRAVELING HOIST, BRIDGE SHOP.

FIG. 11.—HYDRAULIC RIVETER WITH ELECTRIC TRAVELING GANTRY, BRIDGE SHOP.

Axle Shop.—At the lower end of the blooming mill building is located the axle-forge and shop. This contains a 20-ton steam hammer with a stroke of 8 ft., served with two hydraulic, fixed mast cranes, each of 20 tons capacity and two gas furnaces. This hammer, which was originally used for blooming, is now used for miscellaneous forge pur-

the prominent uses being that demanded by air compressors and hydraulic pumps.

The water supply for the steam boilers is largely obtained from dams constructed in the adjoining hills which collect the surface drainage and spring water and yield a supply well suited for boiler use.

Office and Machine Shop.—Fronting on the river are located the main office and the machine shop. The machine shop building is 35 ft. × 230 ft., and is equipped with tools for construction and repairs. Machinery and tools of special design are continually under construction as the development of the work requires. The upper part of the machine shop has a second floor which is used for a toolroom, the remainder being a templet shop. The templet and pattern shop proper is a three-story building located just west of boiler house No. 3 and across the railway tracks from it. These shops are thoroughly equipped with the necessary wood-working machinery. Material is laid out in the shops—both to templet, and also by mechanical spacing—according to the character of the work.

Bridge Shop.—The stock yard for the bridge works is located between the rolling mills and the bridge shop. Its whole area is covered by a system of traveling cranes, each of 6 tons capacity. In the yard are several bending and straightening machines for preparing the material for the shops.

The bridge shop proper is a building of steel skeleton construction 200 ft. wide and 460 ft. long. The walls, excepting where the windows, which form a large part of the sides, are located, are filled with concrete (Fig. 4). The plan of the building consists of a system of central longitudinal girders resting on posts 80 ft. apart. These girders sustain the interior ends of the roof trusses of 100 ft. span, thus leaving a clear transverse opening of 200 ft. wide, except where the few central posts occur. In addition to the usual wall lights, this building is well lighted in its center by a liberal provision of skylights in the roof. Each roof truss is designed to carry a rolling load of 10 tons. There is a complete system of electric traveling hoists suspended on runways, from the roof trusses. Some of these travel the entire width of the shop (Fig. 9), while others travel longitudinally. These hoists are of various designs, adapted to their intended uses, ranging from the light active machine, capable of handling 1 ton, up to one handling a 100-ft. girder weighing 60 tons. The shop contains 16 punches, six shearing machines, and a complete equipment of drills. Notable among these latter are three gantries, each carrying eight radial drills (Fig. 10). These gantries travel longitudinally through the shop, passing over the work operated on. There are also in use numerous portable pneumatic reaming machines and chippers, a hydraulic riveter, two fixed pneumatic riveters and twelve portable air riveters. Two of the riveters are mounted on hydraulic rams which allow a vertical movement of 6 ft. The work is carried through the riveter on an electric traveling gantry (Fig. 11). Besides the compression riveters referred to, there are also several impact air riveters used in places where it is impossible to use the compression riveter. The rivets are heated by petroleum furnaces operated by compressed air.

Planers and milling machines for finishing edges and ends of material are located at convenient points, also boring machines for finishing chords and posts. A pair of rotary planers, each with a 5-ft. cutter head mounted on a bed-plate 70 ft. long, are used to surface both ends of bridge members simultaneously (Fig. 12). The equipment in the bridge shop has been still further perfected by the addition of a multiple beam punch and a spacing punch (Figs. 13 and 14). The beam punch (Fig. 13) carries clusters of punches which at a single stroke perforates for the standard spacing for beam attachments and has also outside punches for the flange punching. The spacing punch is designed especially for punching plates and angles, punching up to ten holes at a stroke and automatically spacing by sixteenths of an inch up to 8 ins.

Electric motors are used for power transmission throughout this shop, the motors in some cases being a unit with the tool driven and in other instances the motor is bolted to a group of tools. The shop is heated in winter by exhaust steam in radiator pipes suspended from roof trusses. The circulation of the steam is promoted by an exhausting pump which draws out all the water of condensation and returns it to the boilers.

The average capacity of the bridge shop is about 5,000 tons per month, requiring 120,000 holes to be punched and 30,000 rivets to be driven per day. The storage yard for finished work is at the upper end of the bridge shop. The material is inspected and painted here. This yard is covered by two traveling cranes of 60 ft. span, each of about 40 tons capacity. These cranes pass over the tracks of both the Pennsylvania R. R. Co. and the Philadelphia & Reading R. R. Co.

Electrical Plant.—The electric motor has acquired an extensive application in the modern steel works. Considering the severity of the work, and the exposed situations in which the electrical appliances must necessarily be placed, as well as the delicacy of the electrical mechanism, the successful adaptation of this method of distributing power is somewhat surprising. These electric motors run successfully close to heated or molten steel, and in the dust and grime of the mill. A class of locomotive machinery has come into service which would be almost impracticable without the aid of electric power.

The general plan of the electrical system consists of a 220-volt distribution used for power purposes, for incandescent and enclosed arc lights, and a constant current system used in the series arc lighting. The electrical generating plant is located just west of the template shop and contains one 200-K-W., 220-volt. generator direct-connected to a 12 × 22 × 42 ins. tandem compound condensing Greene engine, and two 100-K-W., 220-volt generators, each direct-connected to a cross compound condensing vertical engine 10 × 19 × 16 ins. The series arc lighting lamps are of 2,000 c. p. (nominal), and are supplied with current by three 50-light and one 35-light General Electric dynamos belted from Westinghouse engines. The present power plant is being enlarged by the addition of a 500-K-W. generator and direct-connected engine.

The switch-board contains the usual complement of instruments and a recording watt-meter. From the switch-board bus-bars there are 5 distinct circuits running as follows: One to the bridge shop, one to the beam mill, one to the beam mill yard, one to the steel mill, and one to the 20-in. mill. Each circuit and each generator has a separate automatic circuit breaker. In order still further to localize faults as much as possible, automatic circuit breakers are extensively distributed around the principal machines. On these circuits there are over 200 motors aggregating 2,500 HP., and distributed as follows:

	No. of motor.	Total HP.
Electrical repair shop	1	5
Boiler house	1	10
Blooming mill	4	35
Laboratory	3	5
Steel mill	27	350
Bridge shop	74*	800
20-in. mill	16	155
Beam mill	65	930
Two generators	..	50

*32 of these are on cranes.

The two generators last mentioned are driven by an 80-HP. motor and form the Ward Leonard system previously referred to as controlling the tables of the 23-in. mill. The gantry in the bridge shop carrying the work through the 100-ton riveter is also similarly controlled. There are numerous other small motors throughout the works which are not enumerated. At the stock yards at the extreme upper portion of the works there is a 15-K-W. generator, and on the circuit with it are five motors aggregating 35 HP.

The incandescent and inclosed arc system of lighting is run on the power circuit and requires 1,000 incandescent lamps run two in series and about 40 220-volt inclosed arc lamps. The tendency is to increase the incandescent arc system in the central area of the works, partly owing to the better diffusion of light from the inclosed lamp and also because this lamp allows the use of constant voltage current from the power system. In the outlying areas the series arc lamps continue in use, but it is proposed to drive their generating dynamos from direct-connected motors, the current for the latter being derived from the central power generating system, thus making the power generators a unit for electrical distribution for all purposes.

Air and Hydraulic Systems.—Above the storage yard are the air compressors and pumps supplying the air and hydraulic pressure required at this part of the works. There are two supplies of compressed air, one of 10 lbs. pressure used in oil furnaces, and the other of 80 lbs. pressure for riveters, chippers and reamers in the bridge shop. The air is compressed by a number of piston engines of various makes. The Norwalk machines are used for the high pressure and have both steam and air systems compounded.

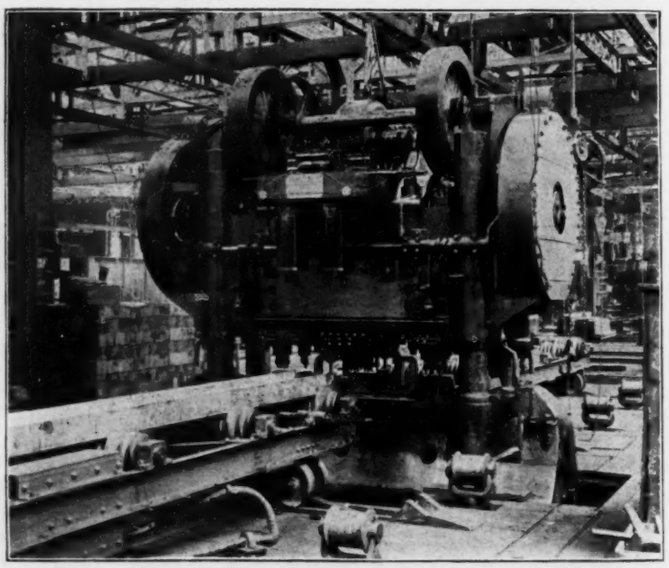


FIG 13.—MULTIPLE BEAM PUNCH, BRIDGE SHOP.

The hydraulic power is also supplied at two pressures of 600 lbs. and 1,300 lbs., respectively. Where required at the individual machines intensifiers which increase the pressure to any desired amount are used. The pumps are all of the duplex Worthington type, with compound condensing steam cylinders.

The hydraulic pressure required at the lower portion of the works is obtained from the pumphouse marked "K," Figs. 1 and 2. This system works at about 500 lbs., and requires two pumps. These are both compound duplex pumps and have

two, 18 ins. × 10 ft. accumulators. From this station the pressure is taken down the river to the steel mill, where the ladle cranes, furnace doors, and the gas and air reversing valves are operated by it, and up the river through the blooming mill, beam mill and stock yards, where it actuates furnace doors, manipulators, transfer tables, turntable, screws on mill boxes, shears, etc.

The billet shear at the end of the blooming mill table, where great rapidity of action is essential, is worked by a steam driver. The steam cylinder is 50 ins. in diameter, the ram 8 ins. in diameter, and the stroke is 9 ft. 4 ins. The steam cylinder has the cut-off controlled by the operator.

Eye-bar Shop.—The eye-bar shop adjoins the bridge shop stock yards and the Compressor and Pump House. It has at present facilities for upsetting 8-in. bars to heads of 18½ ins. diameter, and a new machine is under construction capable of upsetting 14-in. eye-bars with heads of 33 ins. diameter.

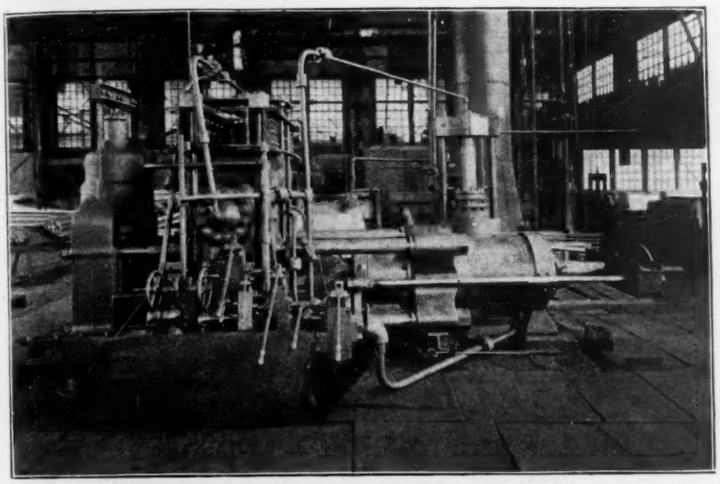


FIG. 15.—HYDRAULIC EYE-BAR UPSETTING MACHINE, EYE-BAR PLANT.

The shop contains four oil furnaces, one heavy hydraulic shear for cutting bars to length, five hydraulic radial cranes, one hydraulic punch for punching eyes, one set of rolls run by hydraulic power for flattening heads after being upset, two boring mills set on the same bed 70 ft. long and used to bore both eyes of a bar at the same time, and an annealing pit of sufficient length to take in the longest eye-bars and having the temperature controlled by oil-burners. A larger annealing furnace and muffle is contemplated in connection with the new eye-bar machine. The present eye-bar machine (Fig. 15) consists of a hydraulic grip which clamps the bar in position in the machine, a second press which lowers and holds the dies in place over the bar, and a third massive press which pushes in the rear die and upsets the bar. An intensifier is used on this machine, which increases the hydraulic pressure from 1,300 to 3,000 lbs. per sq. in. There is also a hydraulic press used for straightening bars.

In this shop is also the hydraulic crimping and forming press (Fig. 16). This is used in crimping angle stiffeners and in bending or curving. It consists of a vertical press carrying a clamping die and a horizontal press containing the crimping or forming die. This machine is coupled to a multiple intensifier, by means of which the pressure is graduated for light or heavy work.

Testing Laboratories.—The chemical laboratory is located near the steel mill. All the analyses of ores, metals, coals and gases for the works are made here. When making soft steel, samples are taken from the furnace before tapping. The samples are forged and fractured and from the appearance of the fracture the melter judges if the phosphorus is as low as required. When the metal is cast a sample is taken, and before the metal is rolled a chemical analysis is made and the carbon, sulphur manganese and phosphorus determined. When hard steels are made, samples are taken and analyzed for carbon before the furnace is tapped. In all cases complete records are kept of the charge, duration of heat, product, analysis and melter. All ingots are given a number which locates the furnace and heat, and these numbers are marked on the finished product.

The physical tests are made in the same laboratory. The apparatus for testing the steel consists of a 150-ton Olsen testing machine and two smaller machines. The material tested is taken from the finished product, pieces 18 ins. long being cut from the webs of channels and beams, the legs of angles and tees and the flanges of Z-bars. The cross-section of these test bars run from ½-in. to 1 in. square, excepting the following sections, which are tested full size: Flats up to 3 ins. in width, rounds up to 2½ ins. in diameter, and squares of 2 ins.

A section of this department is equipped with apparatus for making experimental investigations throughout the works. These comprise boiler and engine tests, electrical measurements, the quality of supplied material, etc., and are made periodically to aid in maintaining a high standard of efficiency.

Bolt and Forge Shop.—Above the eye-bar shop is the bolt and forge shop. All the bolts and rivets required by the works, also sleeve nuts and clevises are made in this shop. Small forgings required for bridge work are also made here. A notable feature of modern smithery is the absence of welding which is becoming a lost art. Clevises, sleeve nuts and similar connections are now made from solid steel.

The shop contains two steam hammers, two acme rivet machines, one bolt machine, one triple acme screw cutter, one machine for upsetting clevises, five smith's fires, two spring pointing machines, two hydraulic benders, one power shear, one air compressor furnishing air for the oil furnaces, several drills, lathes and shapers, and a Westinghouse engine driving the shop. The product of this shop is entirely consumed by the bridge shop and amounts to 9 tons of rivets and 4,000 bolts per day.

Stock Yards, etc.—At the extreme upper end of the works is located the iron foundry, now being rebuilt on a more comprehensive scale. On the side near the river lies the mill stock yard and store house for lumber, erectors' material, and finished patterns. In the stock yards are located the saws and shears for cutting material to lengths. The sections are handled throughout the yard by locomotive cranes.

The various departments of the works have a complete telephonic communication through a central station, and the works have communication with the main office and the various branch offices by long distance telephones.

For the information from which this article has been prepared we are indebted to the A. & P. Roberts Co., Philadelphia, Pa., the proprietors of the Pencoyd Iron Works.

THE FRENCH SOCIETY OF CIVIL ENGINEERS.

The French Society of Civil Engineers, according to a long illustrated article in "Engineering," was founded in 1848, by some of the graduates of the Ecole Centrale. The purposes of the society were to throw light upon obscure questions in civil engineering; to assist in developing the applied sciences; to extend professional teaching among workmen and shop-foremen; to insure closer relationship among members; to conduct an employment bureau for members, and to establish a benevolent fund in case of necessity.

The beginning of the society was very modest, and for 22 years a hall capable of seating only 60 persons answered all the purposes of the meetings. In 1872, however, the society numbered 1,000 members, and it built its own house with a lecture room large enough for 200 persons. This house, in the Rue Rougemont, cost about $52,000 for land, building and fittings. The annual revenue of the society, in 1887, was $20,600, with expenditures of $14,520 per year. In 1897 the treasurer reported secured investments of $17,200; balance on hand, $1,200; $12,800 of various debts; $2,000 in literary account; $1,300 in furniture and $208,800 invested in the new house; against this was a loan of $103,000 on the building.

The growth in membership may be summarized as follows: In 1848 there were 134 members; in 1860, 525; in 1872, 1,038; in 1882, 1,984, and in 1897, 3,054. The published transactions and minutes now form 65 volumes, containing more than 800 papers with discussions. The society library numbers 18,000 volumes; and the "Bulletin" of the society is published monthly, with full "Minutes" issued every two weeks.

The first meeting in the present society building was held on Dec. 17, 1896, and it was officially opened in January, 1897. The general arrangement of the house is simple. The basement contains the heating and lighting appliances and vaults for the archives of the society; the ground floor is occupied by the vestibule, the main lecture room and some small rooms; and the main hall was placed on this floor, entering directly from the street, as it is the practice to rent it for concerts and other meetings. In the entresole is a suite of rooms used as a member's club; on the first floor, or the one over the entresole, are the offices and principal committee room, and the second floor is entirely devoted to the library. On a third floor are the living apartments of the secretary.

THE JACQUES PROCESS FOR CONVERTING HEAT INTO ELECTRICITY.

In the summer of 1896 Dr. W. W. Jacques, of Boston, announced that he had solved the problem of the direct conversion of heat into electricity, and had made an apparatus which effected this conversion with the astonishing efficiency of 88%. The genuineness of the invention was said to be vouched for by such excellent authorities as Prof. Cross of the Massachusetts Institute of Technology, Prof. Rowland of Johns Hopkins, Messrs. Stone and Webster of Boston, and others. In an article in "Harper's Magazine" Dr. Jacques described his invention and assured his readers that its success was beyond doubt, and that henceforth power could be generated from coal by his process with vastly better economy than by the steam engine.

In our issue of May 21, 1896, we discussed Dr. Jacques' alleged invention and suggested that it would be a good plan to learn something more about the invention before passing judgment upon it. More than two years have elapsed, however, and the steam engine still turns round, nor is there any present indication that Dr. Jacques' "electricity-direct-from-coal" apparatus will supplant it.

Quite a number of experimenters have studied Jacques' apparatus, but the best explanation of its real character that has thus far appeared was given in a paper recently read by Prof. Langley, of the Case School of Applied Science, before the Electric Club of Cleveland. We abstract the paper as follows:

In its best form the Jacques battery consists of a closed cylindrical iron cell about 6 ins. in

diameter and 2 ft. high, forming one terminal in which is suspended a carbon rod 3 ins. in diameter and some 20 ins. long, forming the other terminal. The intervening space between the sides of the cell and the carbon is filled with caustic soda or potash (NaOH or KOH) kept in a molten state by heat applied by some form of external furnace.

An iron pipe is run down below the surface of the molten potash, and terminates in a rose nozzle. Through this air is forced which rises in fine bubbles through the molten mass and comes in contact with the carbon rod. It was claimed by Dr. Jacques that chemical combination took place between the oxygen of the air and the carbon rod under these conditions resulting in the generation of a current of electricity. With this apparatus it is claimed that a current of 150 amperes at 1 volt was obtained, and the efficiency was about 32%, as compared with the present efficiency of about 9% as obtained in the ordinary way, using furnace, boiler, engine and dynamo. In a special test, in which 100 cells 12 ins. deep and 1½ ins. in diameter was employed, 30 16-c. p. lamps were lighted for 18¾ hours. During this time the average pressure was close to 90 volts, the current 16 amperes and about 8 lbs. of carbon were consumed in the cells. That is to say: $90 \times 16 = 1{,}440$ watts $= 1.93$ E. HP. were generated for 18.75 hours at an expense of 8 lbs. carbon or $\frac{8}{18.75} = 0.427$ lbs. per hour or 1 HP. hour was produced for 0.221 lbs. of carbon. Since in a perfect thermo-electric generator 1 HP. hour is produced by the combination of 0.175 lbs. of pure carbon, the efficiency may be given as

$$\frac{.175}{.221} = 79+\%.$$

It will be noticed, however, that no account whatever is taken of the heat required to maintain the solution in a molten state.

The exact source of the electric current in the Jacques cell has been, as already stated, a mooted question, Dr. Jacques claiming that the chemical action between the oxygen of the air and the carbon of the rod formed carbonic acid and the electro-motive force obtained (1.04 volts) agreed with that theoretically obtainable when oxygen and carbon combined to form C O_2.

To determine the action taking place in the cell and thus afford a final settlement of the dispute a test was undertaken in which the specifications for the Jacques cell in the inventor's patent were followed exactly and the data obtained during a series of experiments forms the basis of a thesis presented by Messrs. H. S. Rosewater and W. H. Oldham, of the Case School. These experiments are described as follows:

A fire brick furnace was constructed to protect the gas flames used in heating the cell. This was 2 ft. 11 ins. × 2 ft. 6 ins. by 2 ft. 6 ins. deep. In the upper position was placed the cell made of a section of 4-in. iron pipe 12 ins. long, with a cap over the lower end. The carbon rod and pyrometer were suspended in this and later rods of other materials, such as copper, iron, etc., were substituted. The necessary heat was supplied by a special gas burner made by mounting 15 ordinary Bunsen burners on a circular base. Air was supplied through a piece of gas pipe, closed at its lower end and drilled full of holes, which was dipped into the solution. The blast was regulated by throttling until no splashing occurred. To measure the temperature of the solution a pyrometer was constructed and carefully calibrated. This consisted of a 24-in. piece of ¾-in. pipe, at the lower end of which was placed a coil of platinum wire wound upon a clay pipe stem arranged to project partly through the asbestos plug. By keeping the current constant a direct measure of temperature changes was given by the voltage of a circuit of which the coil was part. Calibration was done in an oil bath, using accurate mercury thermometers. The other instruments were a milli-ammeter, an ammeter reading to 5 amperes and a voltmeter reading to 5 volts.

The accompanying cut represents the apparatus used. In this it will be noticed that the voltmeter V is arranged to read either the electro-motive force of the cell or the difference of potential at the terminals of the pyrometer, the former obtained by opening S S and closing K K, the latter by opening K K and closing S S. The current flowing in the battery circuit when L was depressed was measured by the ammeter A, and that flowing in the pyrometer circuit was indicated by the ammeter A_1, the current being obtained from a storage cell and regulated to about 0.25 amperes by means of an acidulated water resistance.

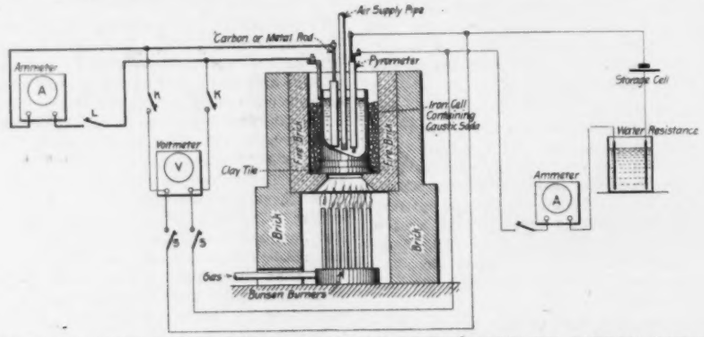
The readings were taken in a regular order throughout the seven experiments, which were as follows: A copper rod suspended in the solution without air blast; same with air blast; an iron rod without blast and again with; a carbon rod with air blast, then without; and, lastly, a carbon rod without blast but with about an ounce of $NaNO_3$ added to the solution to accelerate the oxidization of the carbon.

Each experiment extended over a period of something over four hours. The figures resulting from these tests were plotted on cross-section paper with the time as abscissas and the temperature and voltage as ordinates, and a study of the curves thus obtained developed a number of interesting facts. In every instance the curves resembled thermal curves. At the start, with no air blast, when the solution is cold and the iron cell hot, the difference of potential between the cell and rod is greatest. As the heat is transmitted through the solution and the whole cell becomes nearer an average, but higher, temperature the difference of potential falls off. Toward the end of the run, when the heat was shut off, the curves show the opposite effect, the temperature of the cell being less than the solution, and at the same time the difference of potential again increases. In other words, the maximum difference of electrical potential occurs when the temperature difference is greatest. The addition of air, tending as it does to cool the solution and rod, would increase the difference of temperature and therefore the difference of electrical potential, a fact noticed in the experiments. The same effect would also be noticed with any gas. On the other hand, if the action were chemical or galvanic, as claimed by Jacques, and the oxygen present in the solution produced negative curves, it would be expected that the addition of oxygen by supplying air would make the curves still more negative. This, however, did not occur.

These conclusions are borne out by a paper read by Mr. C. J. Reed before the American Institute of Electrical Engineers, at its meeting on April 27, 1898. In this, what is termed the thermo-electric battery is described, in which the elements are much the same as those used by Dr. Jacques, i. e., an iron cell using sodium or potassium hydrate (NaOH or KOH) and iron or carbon rods. Mr. Reed, however, uses two rods as the elements. In conclusion, Mr. Reed devoted considerable space to a series of curves, which are plotted from values obtained by Liebenow and Strasser,* in a series of experiments in which they used metal cups, iron and nickel, and alkali hydrates with carbon, iron, nickel, steel and silver rods. The results obtained were plotted in the form of curves. Unfortunately, Liebenow and Strasser did not perceive the full force of these experiments, and the relation between the curves of temperature and electro-motive force was not apparent because of their manner of plotting the data. Speaking of this, Mr. Reed says:

> When the intensity of the electromotive force is compared directly with the temperature, instead of inversely (as was done by Liebenow & Strasser), the relation becomes apparent and a diagram thus constructed shows decidedly that the electromotive force increases and decreases with the temperature of the electrolyte. From the nature and arrangement of the apparatus we know that the difference of temperature between the electrolyte and the rod will also increase and decrease with the temperature of the electrolyte. * * * * In the same paper the further statement is made, still considering the work of Liebenow and Strasser:
>
> A second group of most instructive experiments with metal rods substituted for the carbon rods demonstrate in an equally convincing manner that a change in the temperature of the electrolyte produces corresponding change in the electromotive force.

It appears to be quite clear from the foregoing that Dr. Jacques' elecfric generator, which was to revolutionize the art of obtaining power from coal is really an ordinary thermo-electric battery with an efficiency which is probably as low as that of most thermo-electric batteries. One wonders how the eminent men who vouched for the Jacques battery two years ago failed to discover this fact.



APPARATUS USED TO TEST THE PRINCIPLE OF THE JACQUES' CARBON BATTERY.

RAILWAY CROSSING COMPUTATION.

Several articles upon railway-crossing computation having recently appeared in this journal, our attention has been called, in this connection, to a short method proposed and used by Mr. L. K. Vial, late Chief Engineer of the Ajax Forge Works, of Chicago, and Prof. R. B. Ketchum, of the University of Illinois. The method is given in full in the "Technograph," for 1897-98, published by the engineering societies of the University of Illinois, but the following abstract will sufficiently explain the process proposed:

The three general cases considered are: (1) The crossing of two tangents; (2) the crossing of one tangent and one curve, and (3) the crossing of two curves. The solution requires the finding of the frog angles and the chord lengths between the frog points, with the angle of intersection of the center lines of the two tracks and the degree of curvature, or the radius, given. The basis of the advantages claimed for the new solution is embodied in the statement that: Any chord length equals the product of the gage and the cosecant of the mean of the adjacent frog angle. This is expressed algebraically, as follows:

$$\text{chord} = g \csc \frac{A + A'}{2}. \qquad (1)$$

Where g is the gage and A and A' are the frog angles adjacent to the chord. This equation is rigidly true for all chords in the crossing of two tangents, and the chords connecting the two tangents, in the second case; but is approximate only for the other chords of Case 2 and for all the chords in the crossing of two curves. The equations given are as follows:

Case I.—Crossing of Two Tangents.

Fig. 1.

For the frog angles we have $F = f_1 = f_2 = f_3 = f_4$; for the "chord" lengths, we have $f_1\ f_2 = g \csc F$; or, for sake of analogy to equation (1), $f_1\ f_2 = g \csc \frac{f_1 + f_2}{2}$. Similarly for the other three chords.

*Zeitschrift fur Elektrochemie, Feb. 20, 1897.

Case II.—Crossing of One Tangent With One Curve.

For the frog angles we have, noting that M = R cos F and m_1, m_2, m_3 and $m_4 = M = R \cos F$:

$$\cos f_1 = \frac{m_1}{r_1} \quad (2) \qquad \cos f_2 = \frac{m_2}{r_2} \quad (3)$$

$$\cos f_3 = \frac{m_3}{r_3} \quad (4) \qquad \cos f_4 = \frac{m_4}{r_4} \quad (5)$$

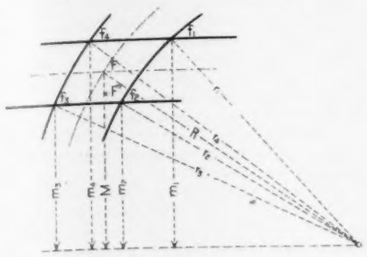


Fig. 2

For the chord lengths we have from equation (1), $f_1 f_2 = g \csc \frac{f_1 + f_2}{2}$, and similarly for the other three chords.

Case III.—Crossing of Two Curves.

Frog Angles.—After solving triangle OO¹ F for OO¹ (= D), we have from triangle OO¹ f_1,

$$\tan \frac{f_1}{2} = \frac{1}{S_1 - D} \sqrt{\frac{(S_1 - D)(S_1 - r_1)(S_1 - m_1)}{S_1}} \quad (6)$$

from triangle OO¹ f_2,

$$\tan \frac{f_2}{2} = \frac{1}{S_2 - D} \sqrt{\frac{(S_2 - D)(S_2 - r_2)(S_2 - m_2)}{S_2}} \quad (7)$$

from triangle OO¹ f_3,

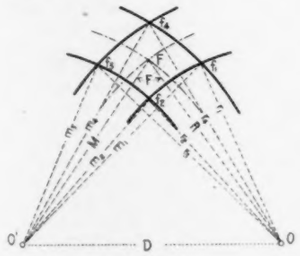


Fig. 3.

$$\tan \frac{f_3}{2} = \frac{1}{S_3 - D} \sqrt{\frac{(S_3 - D)(S_3 - r_3)(S_3 - m_3)}{S_3}} \quad (8)$$

from triangle OO¹ f_4,

$$\tan \frac{f_4}{2} = \frac{1}{S_4 - D} \sqrt{\frac{(S_4 - D)(S_4 - r_4)(S_4 - m_4)}{S_4}} \quad (9)$$

where D, r and m are the known sides, and S the half sum of the sides of the triangle corresponding to the frog angle in question.

For chord lengths, we have, from Equation (1), $f_1 f_2 = g \csc \frac{f_1 + f_2}{2}$, and similarly for the other three chords.

The original article shows the degree of accuracy and the limitation of the application of Equation (1), and also gives two tables for corrections to be applied only in extreme cases. As a general statement, Equation (1) is practically correct in all cases where either or both curves have radii exceeding 700 ft., and it is practically universal in its application to general railway work.

ARE HIGH STEAM PRESSURES ECONOMICAL FOR STATIONARY ENGINES?

In April last an interesting ceremony took place at the Bellevue Hotel, in Philadelphia, when a bust was unveiled of Chief Engineer B. F. Isherwood, U. S. N., in the presence of a large party of well-known engineers, including many who were formerly connected with the Navy. A complete report of the speeches made on this occasion was given in the "Journal of the American Society of Naval Engineers" for May. Among the speakers on that occasion was Dr. Chas. E. Emery, whose sudden death only two months later our readers will recall. Dr. Emery, in his address, gave some interesting reminiscences of his services under Chief Engineer Isherwood during the war, and then followed with a discussion of some of the principles which Isherwood's investigations first established, which is of much interest and deserves careful thought and consideration by all interested in steam-engine design. We quote this portion of Mr. Emery's address in full as follows:

It appears probable that investigations, of the character early made by Mr. Isherwood, may reveal results in relation to our modern steam engineering somewhat similar to those he early established. He showed that, under the conditions obtaining in the engines he tested, it was most economical to limit the expansion of steam, and consequently the size of engines, more than had previously been the custom. We can now see that the proportions adapted for low pressures were not the most economical for higher pressures, but it is a grave question if any actual loss during average working resulted from this. We had in our practice for the first time boilers which would supply all the steam the engines could work off, consequently the maximum speed could be obtained at any time and continued indefinitely. This was something new for a steamship. It was something to be sought for and not readily found, even in the present. Undoubtedly the economy was not the maximum, when the machinery was forced to its utmost, but this occurred very rarely, probably not 1% of the time, whereas the engines were of proper size to secure the maximum economy possible during the long periods requiring moderate power, so the average results were as good and generally better than would have been obtained with any other adaptation of simple machinery using the steam pressure available.

It is evident to me that the same principle can be applied in the proportions of our modern compound engines. Some have realized it, and it is not uncommon on the more noted of the transatlantic steamers to hear the safety valves blow for a short interval after changing watches and cleaning several fires, showing the close adaptation of the engines and boilers. On the contrary, I was on a yacht recently, designed to run with 200 lbs. of steam, which had engines so large that when linked up and running at full boiler power it was necessary to keep the throttles nearly closed. The advantage of keeping the engines rather small for the work and the boiler power ample, as in Mr. Isherwood's practice referred to, will be evident to all, on account of the very superior economy obtained in running during the greater part of the time at reduced power.

Further than this, I believe that the limit of desirable steam pressure has been reached, and that possible economy in a scientific rather than a theoretical sense would be attained by not attempting the higher pressures now found practicable. I recently had occasion to investigate a number of compound engine plants operating factories in the East. The one that was most vaunted and claimed to be securing a horse-power for 1.3 lbs. of coal, required 2½ lbs. Several others required over 2 lbs., and in only one case did the cost fall as low as 1¾ lbs., and this was one of the earlier engines designed as the immediate results of the analysis I published of experiments with compound and non-compound engines, made, under the direction of Mr. Loring and myself, with engines of different kinds on revenue cutters, which I designed so as to make such a test practicable 24 years ago, and before the revival of the compound engine here and its application to vessels of the U. S., Navy. The proportions of the cylinders of the factory engine referred to were more nearly like those I had used for lower pressures and set forth in my analysis, and the water consumption for this long-stroke engine, small clearances and a steam pressure of 125 lbs., was 16 lbs., the chief economy being in the boilers, whereas the compound engine of the series I designed so long ago gave a horse-power for 18.4 lbs. of water per HP. per hour with only 70 lbs. steam pressure. It is certain that these modern engines with high steam pressures will, under experimental conditions, do 25% to 33% better than the figures stated, but it is equally certain that they do not do it under the conditions of ordinary practice. The same general results are shown on shipboard, notwithstanding there is the same talk about getting a horse-power for 1.3 lbs. The fact is that few steamers use less than 2 lbs. per HP., and the average is higher than that. In some cases, with particular provisions for securing economy from the boilers, better results have been obtained, but it is a question whether any special mechanism is proper for use on a naval vessel liable to the exigencies of war.

Since the average cost of a horse-power is already considerably above 2 lbs., and as this is as true for engines carrying 200 lbs. of steam as for those carrying 125 lbs., the general result, independent of particular cases, is that it is not desirable to carry the higher pressures, with their attendant increase of radiation, liability to external leakage, and particularly the liability to large wastes by inconsiderable leaks in the cylinders and valves and the increased wear and friction of high-pressure packings. If this general proposition be true, another incidental advantage follows to which I have already called attention in the Journal, viz., the possibility of abandoning the intermediate cylinder of a triple-compound engine and the restoration of the 2 or 3-cylinder compound engines, properly proportioned to do the work economically. The triple-compound engines are particularly unfitted for variable powers. This is recognized in the Eastern mills, and compound engines are used exclusively to assist waterwheels even for pressures up to 180 lbs. The compound engine with pressures exceeding 150 lbs. would not be desirable on shipboard, as proper results could not be secured with a simple valve gear, but with lower pressures there would be no trouble whatever in using such engines even with simple lap-valve cut-offs, and the worst penalty to secure best economy would be an independent cut-off for the small cylinder, as in my design of 24 years ago. These suggestions are not criticisms of the policy of anyone. We desire to compliment the present management of the Bureau and express our love for its Chief, but only by suggestion, discussion and investigation can the truth be known. The suggestions are made here because they are in the line of Mr. Isherwood's earlier work, and a correct principle lives through all time.

I have, however, thus far neglected to state that, although the high steam pressures do not give increased economy in practice, they have enabled the mean pressure, referred to the large cylinder, to be increased from 25 up to 40 lbs., and in small engines up to 50 lbs., which, with higher speeds, better material and closer design, has so greatly decreased the size and weight of steam machinery. This has been partially defeated in many cases by attempting with higher pressures greatly increased expansion, which, though economical on a test, is a blunder for variable power and long continued use where minor repairs cannot be promptly made. We must recognize that, in the suggested decrease of pressure, which can certainly be obtained without decreasing the economy in actual practice, we must not increase the size of engines so that, even without the intermediate cylinder, they will be heavier than those for which they are substituted. Just where the limit is, cannot be determined in a hasty discussion of this character. I only wish to call attention to the fact that apparently such a limit exists and that the efforts of thinking engineers can well be directed to its exact definition under particular conditions.

RATIONAL FORMULAS FOR THE STRENGTH OF COLUMNS.

A paper by Mr. Carl G. Barth, entitled "An Investigation into the Strength of Columns, Leading to Some New Formulas," read before the Engineers Club, of St. Louis, Mar. 16, 1898, and printed in the "Journal of the Association of Engineering Societies" for April, contains a long mathematical investigation of the subject, and presents some working formulas both for concentric and for eccentric loads. The basis upon which the work proceeds is stated as follows:

Evidently all we can look for in a rational column formula is that it shall enable us to determine a load that will subject a fairly well-made and properly arranged column to no undue stress, even if that load should accidentally be applied at some reasonable distance out of center.

The formula herein to be proposed is of that nature, and has been derived by considering all the uncertainties of a practical column (such as possible imperfections in its material and form, and any possible eccentric displacement of the load) as equivalent to a certain amount of initial eccentricity of the load on an otherwise ideally perfect column.

The author's final formula for concentric loading, reached after making some approximations for the purpose of simplifying a much longer formula, is:

$$p = \frac{f}{1 + \frac{9}{\pi^2}\frac{f}{E}\left(\frac{l}{r}\right)^2} = \frac{f}{1 + 0.912\frac{f}{E}\left(\frac{l}{r}\right)^2}$$

in which p = permissible working load per square inch of cross-section of the column, f = permissible working stress per square inch of section of an exceedingly short practical column, E = modulus of elasticity of the material, l = length, and r = least radius of gyration, both in the same units.

For eccentrically loaded columns he obtains:

$$p = \frac{f}{1 + \frac{w\,a}{r^2} + 0.912\frac{f}{E}\left(\frac{l}{r}\right)^2}$$

in which w = distance from the center at which the load is applied, and a = distance from the center of the section to its most remote fiber.

We cannot spare the space for even an abstract of the analysis by which the formulas are derived, but must refer those who are interested in the subject to the original paper.

This has been reprinted in a separate pamphlet, copies of which can be obtained, we presume, by addressing Mr. Barth, at 337 Harrison Ave., Scranton, Pa.

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Entered at the New York Post-Office as Second-Class Matter.

Published every Thursday

at St. Paul Building, 220 Broadway, New York, by

THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, - - - - - - - - - PRESIDENT
D. McN. STAUFFER, - - - - - - - VICE-PRESIDENT
CHARLES WHITING BAKER, SECRETARY AND MANAGING EDITOR.
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ALFRED E. KORNFELD, New York,
F. A. PECKHAM, Chicago,
S. B. READ, Boston, } ADVERTISING REPRESENTATIVES

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 299 DEVONSHIRE ST.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $7.60 (31 shillings); Thin Paper Edition, One Year, $6.31 (26 shillings). SINGLE COPIES of any number in current year, 15 cents.

In ordering changes of mailing addresses, state BOTH old and new addresses; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 328 means that subscription is paid to the 32d week (that is the issue of Aug. 11) of the year 1898; the change of these figures is the only receipt sent, unless by special request.

ADVERTISING RATES: 20 cents per line. Want noticces special rates, see page 18. Rates for standing advertisements sent on request. Changes in standing advertisements must be received by Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements by Wednesday noon.

The entire success of the conduit electric railway system in New York city and in Washington is likely to lead to demands upon electrical railway companies in other cities to remove their poles and overhead wires and substitute the conduit system. As it happens, the franchises under which not a few street railway companies are operating, contain a provision that when any system of electric street railway operation is perfected and proved to be practicable which dispenses with the use of overhead wires, the company may be required by the municipal authorities to alter its lines to that system. The rigid enforcement of this requirement would generally be a serious thing for the street railway companies; and in many cases we believe the real interests of the city which has the right to require such action by its street railway companies can be better served by a more conservative course. It must be remembered that the cost per mile of the electric conduit construction is very high. It may be roughly estimated at about double the cost of the ordinary overhead trolley system. Many street railway companies would be forced into receivers' hands if required to duplicate their investment in their tracks, with no additional income resulting. It may be said, that that is no affair of the city authorities, their sole duty is to see that the railway does everything which it is obliged to do for the city by the terms of its franchise. This, however, we believe to be a narrow view of the question. If the size of a city and the volume of traffic on its street railways is sufficient to justify the conduit system, then it may be all right to compel the company to install it; where the city has the power. But to bankrupt a city's railway companies will in the long run injure the city and the patrons of its railways, as well as those who own the railways. The prejudice against the overhead trolley system has almost disappeared. The "deadly overhead wire," which was what the public feared most, has an astonishingly small record of accidents against it, as it is now installed in street railway practice. The trolley wires being located in the middle of the street are no such obstacle to the work of firemen as are the electric light, telephone and telegraph wires, which are strung on high poles next the curb. Really, except where streets are so narrow and crowded that the room taken up by the poles is a serious matter, the only objection to the overhead trolley system for street cars is the objection to the disfigurement of the streets. And this disfigurement is by no means so serious as is sometimes claimed. If the street railways were owned by the city, how many taxpayers would be in favor of expending an additional $25,000 per mile of track merely to improve the aesthetic appearance of the streets by dispensing with overhead trolley wires? Certainly the gain to the average citizen from the removal of the overhead construction would not compensate for the loss that will inevitably result from throwing the company into bankruptcy.

Suppose, however, that a company can well afford to introduce the conduit system. Even then we believe that in many instances something better can be done than to force the company to adopt it, where the city has the power. Concessions in the form of reduced fares, especially to school children and workmen, increased transfer privileges, extensions to outlying suburbs in need of better communication, or even increased cash payments to the city as rental for the use of the streets, would, in most cases, be of much more real value to the citizens than the removal of the poles and overhead wires.

Of course, we are not speaking now of the largest cities. In several of these, space, light and air in the streets have become so valuable that the substitution of the conduit in place of the overhead system ought to be made, and doubtless will be in the near future.

The smoke nuisance, due to the use of soft coal, has reached Scranton, Pa., the chief center of the anthracite region. An ordinance has been adopted in the select council directing the city engineer, building inspector and plumbing inspector to "acquire a knowledge of methods and devices now in use for the purpose of reducing to a minimum the smoke and dust annoyances resulting from the use of bituminous coal, and report to councils at the earliest date possible." The burning of soft coal in Scranton is worse than "carrying coals to Newcastle." About two years ago the Scranton papers were full of claims that the anthracite culm piles in and near that city were a storehouse of the cheapest fuel in the country, that the culm could be made into gas, and the gas used to generate power at a cheaper rate than water power could be furnished at Niagara Falls. And now it appears that it is found cheaper, by some of the Scranton people at least, to burn soft coal obtained from a distance of say 200 miles, than to burn the culm which may be had in the city for 25 cts. a ton. We in New York city can sympathize with Scranton in this matter, for the use of soft coal here is increasing steadily, and complaints of the smoke nuisance have become quite common. One method of getting rid of the nuisance has occasionally been tried here with success, which may be commended to the attention of the Scranton officials who have been directed to "acquire a knowledge" of the subject. It is an ordinary suit in court brought by any individual who is aggrieved, praying for an injunction restraining the offender from using it in such a way that it will emit smoke and cause a nuisance. Such injunctions, we understand, have been granted on the ground of the common law respecting nuisances, that no man has a right to maintain a nuisance that injures his neighbor's property or destroys his comfort, and offenders have been compelled to abandon the use of soft coal and return to anthracite.

PIONEER RAILWAY CONSTRUCTION IN NEW COUNTRIES.

The course of recent events appears to indicate that within a few years the great empire of China may offer a new field to the American engineer and merchant, and that the overthrow of Spanish misrule and medievalism in the West Indies and the "Far East" will also lead to possibilities of rapid development of American interests in these smaller fields. Development in such cases means, first of all, the introduction or extension of the railway. While the American engineer in his own country has shown his ability to build light and inexpensive railways for development purposes, and to improve these lines in proportion as the traffic increases, he has so far had but little opportunity to exercise this ability in other countries, with the exception of Mexico. It is true that he has built railways in the West Indies, in Central and South America, and in the Hawaiian Islands, and is building one in Korea, but most of these have been short lines, built to accommodate an existing traffic from mines, or along established routes of travel, rather than to serve as lines of general development. Already American engineers have been established as advisers in railway affairs in China, and should the recent war with Spain result in giving the United States a permanent foothold in what is termed in Europe "the East," there is little doubt but that American interests in China will experience considerable benefit. It seems appropriate at this time, therefore, to give some consideration to the general question of the construction of pioneer railways in new countries, and particularly in China.

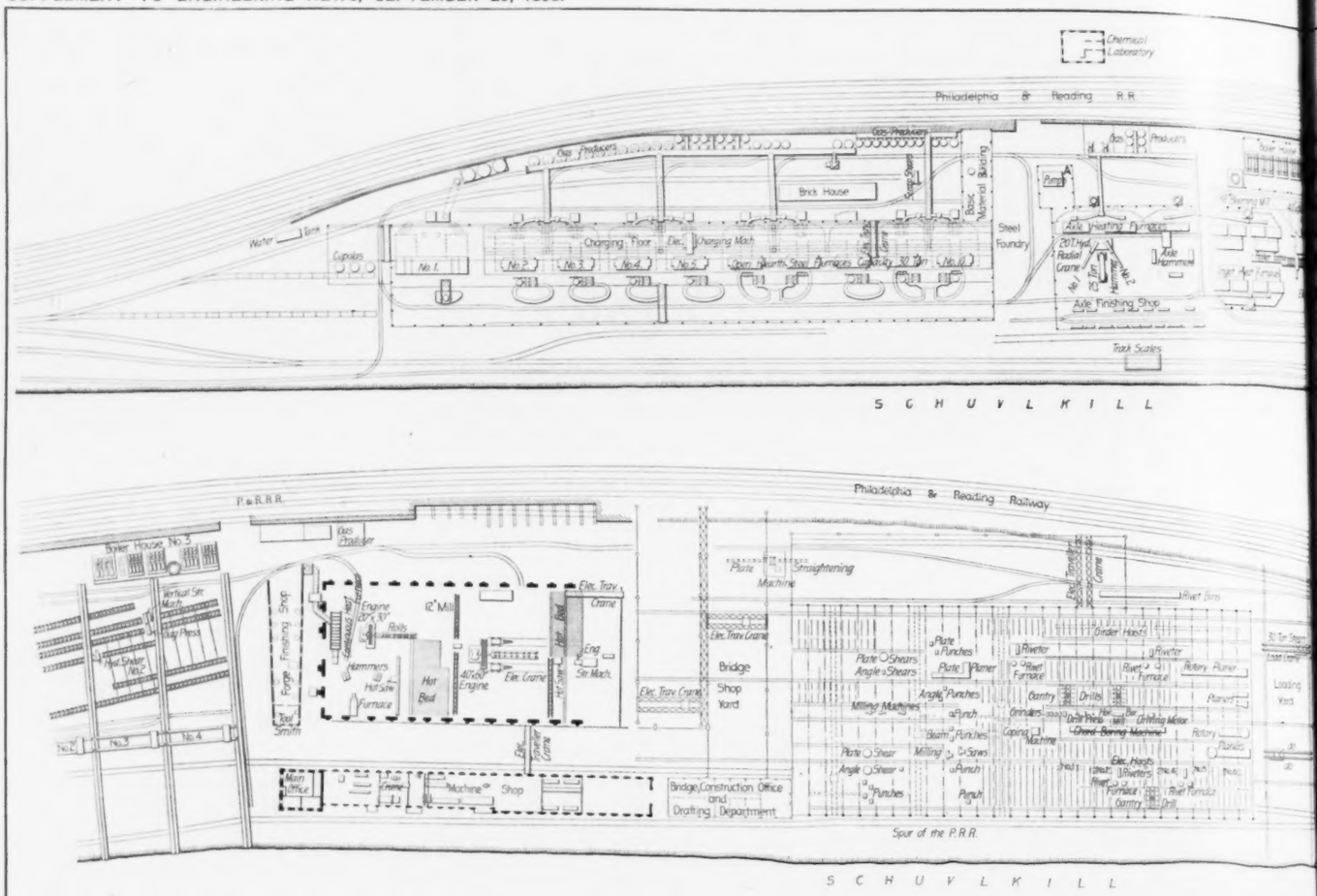
For many years past there has been a great deal of energy expended in promoting railway schemes in China, most of which had practically no result. Every large European country has tried to force railways upon China, and there have been not a few American schemes for this purpose. For a long while the Chinese have stolidly and steadily rejected all propositions, and the most that has been done has been gradually and very slowly to build the lines now known as the Imperial Railways of North China, less than 300 miles in length, and extending from Tientsin to Pekin, and northeast to a point beyond Shan-Hai-Kwan. Two other short lines are also making slow progress.

Within very recent years, however, and especially since the war with Japan, there have been signs that the Chinese will eventually permit their country to be opened up by railways, and the result has been that renewed efforts have been made by professional promoters and by representatives of various foreign governments to obtain important concessions. At the present time a great number of lines are projected, but little is known as to the probabilities of their construction, although the appointment of an American consulting engineer to the Director General of Railways may be assumed to indicate that there is already some appreciation of American skill in railway construction.

In India, Australia, and Siberia, the railways have been introduced by one nation, and that the dominant nation, and the work has, therefore, not been subject to the interference of outside influences. The same is in the main true of Africa, although the number of petty states bordering upon the great territory held by the British have caused some political complications.

In China, however, the conditions will be very different. That nation will do none of the work itself; in fact it has no men competent or experienced enough to plan or direct such work, and it must, therefore, rely almost entirely upon foreigners for its railway system. As a result of this the Chinese government has already been subjected to severe pressure from various other nations, each of which will probably get some share in the distribution of concessions, and it is impossible that all these varied interests should work harmoniously together. Already a war cloud has been raised in Europe by differences over the diplomatic negotiations for railway concessions in China. The government apparently cannot foresee that which seems to outsiders to be the inevitable outcome of this sort of competition. It has evidently no determined policy on the railway question, and is seeking to play off the various Powers against each other, which is a dangerous practice.

In the various discussions upon this subject, one very important point seems to have been almost entirely ignored, and that is the relative character and competence of men of the different nationalities interested to build railways suitable to the conditions prevailing in China. It is essential that the lines should be made as cheaply as possible



FIGS. 1 AND 2. GENERAL PLAN OF PLANT.

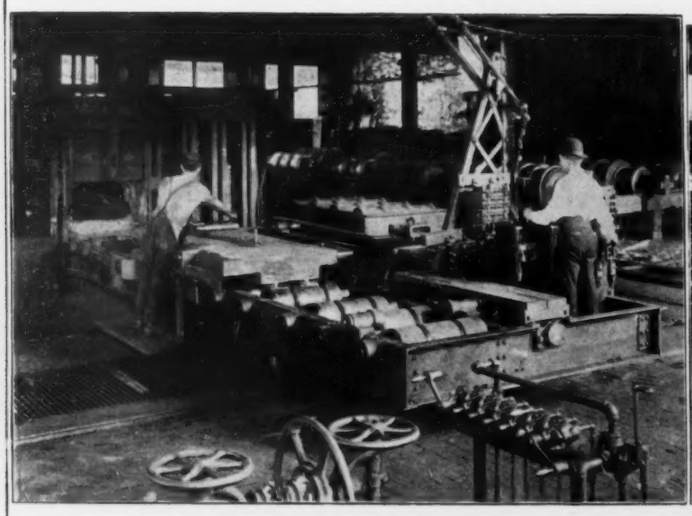
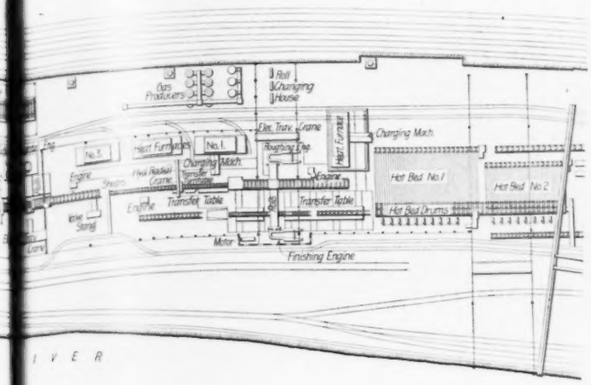


FIG. 6. ELECTRIC CHARGING MACHINE AT REHEATING FURNACE, BEAM MILL.

FIG. 8 ANGLE STRAIGHTENING ROLL.

PENCOYD IRON WORKS, PENCOYD, PA.

(A. & P. Roberts Co., Philadelphia, Pa.)



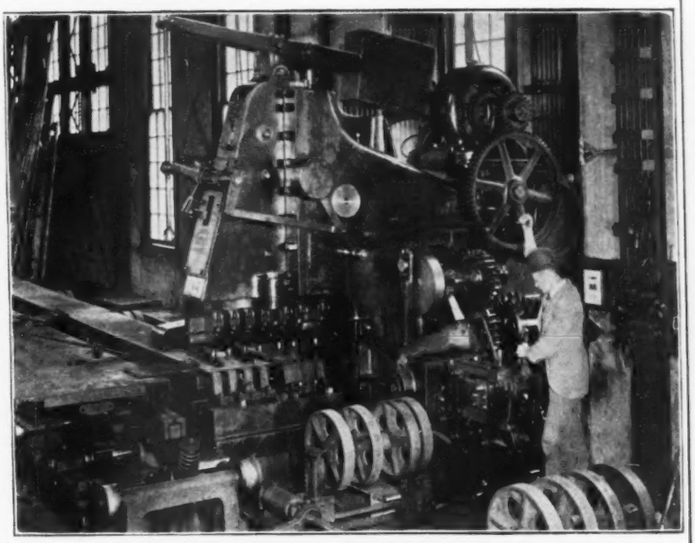
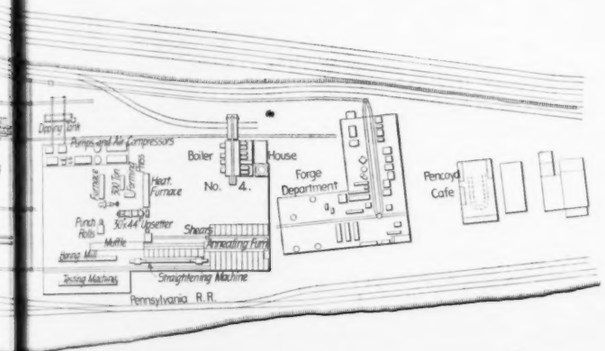


FIG. 14. AUTOMATIC SPACING PUNCH, BRIDGE SHOP.



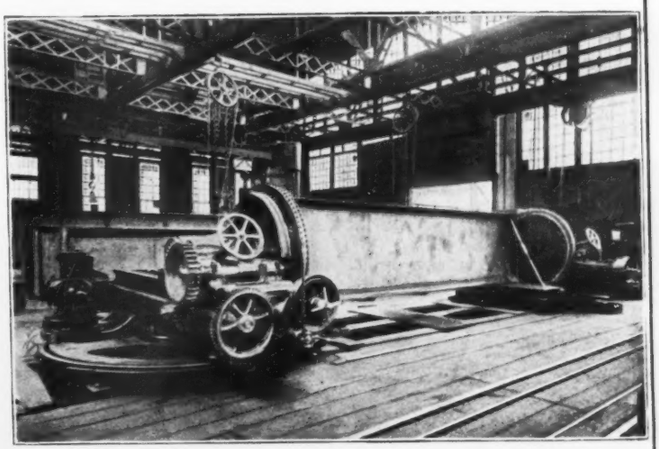


FIG. 12. DOUBLE HEAD ROTARY PLANER, BRIDGE SHOP.

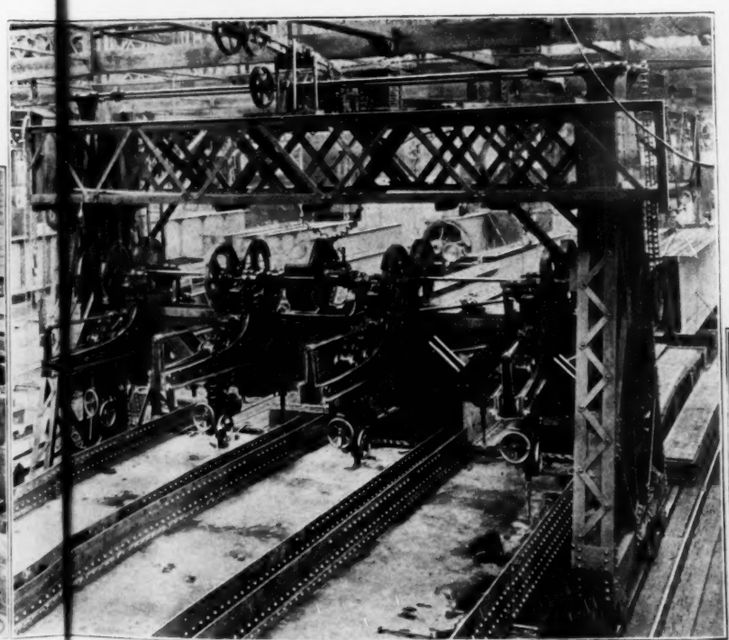


FIG. 10. GANTRY CARRYING EIGHT RADIAL DRILLS, BRIDGE SHOP.

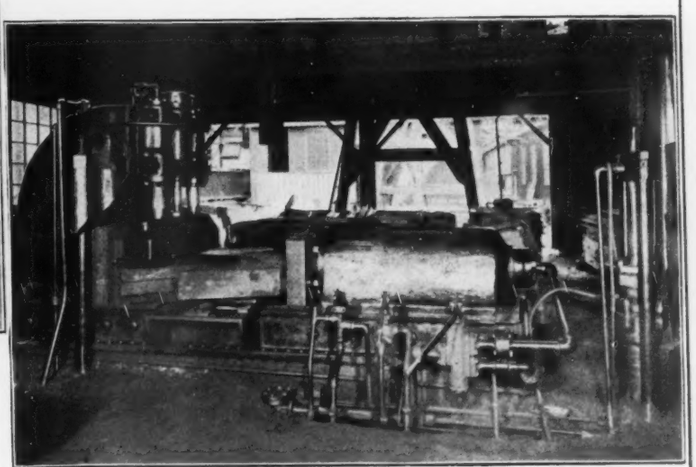


FIG. 16. HYDRAULIC FORMING MACHINE, EYE-BAR PLANT.

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with due regard to efficiency and safety, since the vast majority of the people are extremely poor, and most of the railways will be lines of development, the fundamental principle of which is that the greatest length of line should be built in the shortest time and with the least expenditure of money. It is, we think, not too much to say, that American engineers are pre-eminently qualified to undertake this character of construction, since they have shown by their works that they understand and can act upon this principle, avoiding, on the one hand, the Scylla of unnecessarily good lines built at large cost and great expenditure of time, and, on the other hand, the Charybdis of purely cheap lines, as speculative enterprises, which can hardly be included in the term engineering works.

The greatest amount of railway building in new countries has been done by English engineers, but while their work has been good, it has in very many cases been much more expensive than the existing conditions have warranted, and they have shown a tendency to build a limited mileage of first-class railway, rather than an extensive mileage of railway of a character more suited to the traffic. This matter was discussed in our issues of Aug. 4, 1892; Dec. 22, 1892; and April 6, 1893. For lines intended to develop and open up a new country this system is essentially wrong.

In India and Australia the policy of slowly building lines of the most substantial character, and with handsome and costly structures, was followed for several years. In this connection it is interesting to note that in the early days of railways in India, Col. Kennedy, a military engineer who was sent out to report on the introduction of railways, proposed that the Bombay, Baroda & Central India Ry. should cross the flat alluvial districts on its line by means of iron viaducts with 60-ft. spans of through Warren girders on screw-pile piers, each pier to consist of three vertical piles, with batter piles on one or both sides at the crossings of non-tidal or tidal rivers, respectively. This system has been much used in India, but the fact of its recommendation for the first lines in a new country, requiring the importation of thousands of tons of ironwork from England, seems to show that Col. Kennedy was not the right sort of engineer for pioneer lines. In fact, it was this gentleman who, in 1851, prepared a report in which he laid down a series of rules for railway construction in India, which is remarkable for its complete disregard of economical considerations. In this report he recommended that the new Indian railways should have maximum grades of 1 in 2,000 for main lines, and 1 in 330 for branch lines, with "impulsive planes" to assist the ascent. The consulting engineers, however, disapproved of "impulsive planes," and recognized the fact that such limitation of grades was uttterly impracticable, since it would often be far more economical to build a short line with heavy grades than a long line practically level, especially in mountainous districts.

In India some of the trunk lines were of very expensive and permanent construction, and some of the large flood areas are crossed by railways on high embankments with immense high level bridges and an extraordinary number of flood openings, entailing enormous cost. It must be remembered, however, that the conditions there existing differed very considerably from those of Australia, Japan and Africa. The military and strategic necessity for railways in India was a most important consideration, fully equal to that of their necessity for development purposes, and in many cases this fully warranted the enormous expenditures involved in the great works which were required to ensure uninterrupted communication. Still, there are many railways in India which have been built in an unnecessarily expensive manner. In fact, the type and cost of construction of the early railways in general, in that country, was far beyond what was necessary, and an enormous loss of life in the terrible famines has been attributed largely to the fact that the authorities devoted their attention to building short lengths of excellent and costly lines rather than to building a comprehensive system of lines of communication.

In Australia the special advantages of the construction of light and cheap railways for development purposes are being more generally recognized, and in 1893-97 Mr. M. C. Kernot, Engineer in Chief for the Government Railways of Victoria, had several such lines built in that colony at a cost of less than $10,000 per mile. These were in districts where the ordinary passenger and freight traffic was light, and the railways carried wheat and agricultural produce to the seaboard. Seven lines, aggregating 192 miles in length, showed a cost per mile ranging from $6,690 to $10,805, the average being $8,840 per mile. These were of the standard gage of the colony, 5 ft. 3 ins., and had 60-lb. T-rails on eucalyptus ties 9 × 4½ ins., 9 ft. long, lasting 25 years. The bridges and box culverts were of timber. Even this low cost could have been further reduced by the use of plows, scrapers and grading machines; but in order to furnish work for the unemployed of the large towns, all the grading was done by pick and shovel, wheelbarrows and teams. Small contracts were let to gangs of men, each gang appointing its own foreman, but the entire gang shared equally in the earnings. The work was mainly in level country with occasional sand hills and ridges. The annual rainfall of the district is but 14 ins., and the water is quickly absorbed by the sandy loam. As the question of floods did not enter into consideration, the line was built on low embankments, the earth being compacted by means of water-ballast rollers hauled by bullocks. In New South Wales, also, somewhat similar pioneer lines have been introduced, on which trains are run at low speed, and in order to save the expense of fencing it was determined to run trains only by day. On one line, however, this latter arrangement has been rendered unnecessary by the use of an electric headlight, this being done in order to allow of making certain connections with the main line trains.

It seems not improbable, in view of the actions of the Chinese in the past, that procrastination and obstruction will for many years be the great hindrance to railway construction and will of necessity greatly increase the cost of such construction. There will probably be special boards or commissions on railway affairs, composed of native officials who cannot be expected to understand their duties, or to be competent to direct or advise, all of which will tend to complicate matters and introduce delay and extra expense. These hindrances, too, will be increased materially by red tape methods similar to those which have tried the souls of professional engineers in India for the last fifty years. Sir Arthur T. Cotton, R. E., in his "Public Works in India," 1853, makes the following remarks upon the course of officialdom in that country:

> The motto hitherto has been: "Do nothing; have nothing done; let nobody do anything. Bear any loss, let the people die of famine, let millions be lost in revenue for want of water or roads, rather than do anything." It is not the loss of money that we mind, that is nothing. We can afford to lose millions every year for want of hydraulic works, and therefore to spend thousands on such works would, of course, be nothing. But nothing must be done.

The delays and contingencies due to government regulations and red tape are by no means the only hindrances to rapid and economical construction. The provincial and local authorities will all have more or less power for interference and will cause embarrassments which can only be dealt with by the expenditure of time and money. The character of the people, too, must be taken into consideration, and this is such as to undoubtedly lead them to put many practical obstructions in the way of the work and harass its execution.

While much of the projected work will be in flat and easy country, as on the Shansi and Hankow lines (Eng. News, Aug. 12, 1897, and March 31, 1898), yet, under the conditions already noted, no accurate estimate of cost can be made. Even supposing that a careful estimate is made, with a full knowledge of the character of the country, the style of construction, the labor conditions, and the cost of material, then liberal but indeterminate allowances must be made for contingencies incident to the difficulties of work in new countries, with little skilled labor, and with inadequate facilities for transportation or for replacing material lost or damaged in transit. Furthermore, the general evidence is to the effect that, in China at least, provision must be made for certain payments to a long list of officials. Under these circumstances, estimates based on the cost of construction in other countries are of little value.

The character of construction will, of course, depend largely on local conditions. In a new country the question of gage is one of the first considerations, but the cases are rare in which the standard gage of 4 ft. 8½ ins. will not be the most advantageous, for trunk lines at any rate. The troubles due to lack of uniformity in gage, which are so seriously felt in India and Australia, seem not unlikely to arise eventually in China. The lines now in operation are of the standard gage, as are the two short lines under construction, but the Manchurian railway, which is an extension of the Trans-Siberian Ry., will have the Russian gage of 5 ft. In China, as already stated, the country is largely flat or rolling, so that there will be but little reason for bringing up the stock arguments in favor of a narrow gage.

One important point, however, is that much of this flat country is subject to inundation, and that the railway must either be kept above the flood level by diverting it around on the higher ground and carrying it on viaducts and embankments with flood openings, or must be carried boldly across as a low-level line, traffic on which may be stopped occasionally during periods of high water. This is largely a question of expediency, but though it is a very important question, it is not unfrequently overlooked. For example, we may mention a treatise on "Pioneer Engineering," by Mr. Dobson, an English engineer, in which the question of the relative merits and expediency of high-level and low-level lines is not considered at all. In many cases it will probably be a wise plan to boldly cross the district by a low-level line, conforming as closely as possible to the surface of the ground, and allow traffic to be temporarily suspended during flood times. Of course, if the traffic is heavy enough to warrant the cost it may be better to keep the line as far as possible on high ground and to cross the flood district by trestles or viaducts. An interesting article in relation to the building of high-level or low-level railway lines across districts subject to inundation will be found on another page of this issue.

Under the conditions which prevail in China, it is practically impossible to lay out a system of railways suitable to the general development of the country, but the engineers will have to deal with individual lines along routes prescribed and limited by the concession for each line, and it is not at all improbable that some of these will conflict and be in competition, thus involving an expenditure of money and work which might better have been devoted to the extension of a complete system of railway.

To encourage traffic in a country where wages are so small, the rates must be extremely low, and the cost of construction and equipment must equally, therefore, be kept at a minimum. The improved facilities will undoubtedly induce travel on the part of merchants and others, and the social system is such that it will be impracticable to introduce the American system of uniform rates and accommodation. The increased intercourse, however, will tend to weaken the existing class distinctions, as has been the case in India.

One of the great economic purposes of railways in a new country, is to reduce the cost of transportation far below the enormous cost of slow transportation of small quantities in native wagons and on native roads. This aim can only be attained if the railway is built with a view to the lowest possible charges. Steam navigation on rivers and canals also tends to increase traffic and reduce the cost of transportation, and it is probable that China, like India, will offer a field for this system of transportation. In fact, in April last the Chinese government determined to abolish the restriction on the use of steam power, and to permit foreigners to use steam vessels to navigate the rivers and lakes instead of using only native boats. This will probably prove to be an important concession.

In the planning of a system of transportation, one of the prime considerations is the time in which the means of communication can be completed and put in operation, as the more rapidly it is built and extended the more rapidly will the traffic be developed. Any delay in completing the

line will, on the other hand, be a cause of serious loss. Sir Arthur Cotton estimated that for the construction of 760 miles of development railways in India, there would be a saving of $75,000,000 in cost of transportation by building the line in 15 years at $50,000 per mile, rather than in 30 years at $25,000 per mile, the greater expense being allowed for difficulties in construction, and not for heavier works. In other words, if the cost of transit of the existing traffic, including what is brought to the line in consequence of the improved facilities which it offers, was $12,000 per mile, and could be reduced to one-fourth of that sum by a railway, there would be a loss to the country of $9,000 per mile for every year the opening of the line was delayed.

Train speed is a matter of very minor consideration, the traffic accommodation and capacity of the slowest railway being far and away beyond that of road transit. It will be evident that traffic can be better served and at far less cost by being handled on 500 miles of railway at 10 miles per hour, than on 100 miles on the railway cars at 30 miles an hour, and 400 miles on wagons at 3 miles an hour. What is needed, in the interests of the development of the country, is not speed in operation, but speed in construction, thus giving a system that will naturally reduce the cost of transportation over a larger area of country, rather than one requiring a large expenditure for a small extent of excellent communication. This has been the fundamental principle of railway construction in the United States, and when once the line of communication is completed it can be improved in accordance with the growth of the traffic.

Under such a system, districts having mineral or agricultural resources which are at present practically unavailable on account of the difficulties and cost of transportation, may be quickly developed, and bring a heavy traffic upon the line.

The eminent Indian engineer, Sir Arthur T. Cotton, R. E., who has already been referred to, strongly advocated the construction of cheap railways which could be built rapidly and carry traffic at low speed, the primary object being to open up communication. The following quotation sums up his principles in brief:

> Nothing can compensate for loss of time in opening up the country. What is most wanted is speed, not in traveling on the railways or canals when executed, but in executing them. What is the use of going a hundred miles at the rate of 34 miles an hour, if we must then go on at 3 miles an hour for thousands of miles. To throw open the country 20,000 miles of good common road, to be traveled at 7 miles an hour, and costing only $2,500 per mile, would be of immeasurably greater value than 800 miles of first-class railway at $60,000 a mile, with a speed of 34 miles per hour; since the former could give an average speed through the country more than double that of the latter. Speed is indeed what is wanted, but speed in forming communications, not speed in traveling upon them.

He opposed the government policy of building magnificent roads, and the railway policy of slowly building lines of first-class construction, but strongly advocated cheap railway construction, considering that in regard to the important point of completing a system of communication, such railways have an enormous advantage over common roads, and would cost but little more. The cost of works for a cheap railway, complete to subgrade, would be but about one-fifth that of a good road, and the work could be done in one-fifth of the time, while the laying of track would be done very rapidly. He claimed, and supported his claims by careful calculations, that the time saved in laying such a railway, as compared with making a road, would, on main lines, much more than pay for the railway, and held this up as an argument against going on with the construction of common roads on main lines of travel.

The conclusions arrived at fifty years ago in regard to India, seem to be very directly applicable to China at this time, and may be summarized as follows:

Cheap railways and good common roads will greatly reduce the present cost of transit. In a rich country already provided with a complete system of cheap transit, high speed of transit is a prime consideration, but in a very poor country, with no adequate means of transit at moderate cost, the prime consideration is to provide a general system of cheap transit. The great point, therefore, is to adopt a system of communication which will greatly reduce the cost of transit, and to execute this throughout a large extent of country in the shortest possible time, rather than to make the most perfect communication possible on a few hundred miles in the course of 20 or 30 years.

LETTERS TO THE EDITOR.

The Litigation Over Air Brake Triple-Valve Patents.

Sir: It is reported to us that a statement is being circulated to the effect that the decision of Judge Wallace, of the United States Circuit Court, in our suit against the New York Air Brake Co. for infringement in the manufacture and sale of its present form of triple valve, is a final one. Such a statement is utterly without foundation, as the case in question will not be finally decided until after it has been heard by the Court of Appeals. The hearing before the Court of Appeals is set down for the next term, which opens about the last of October, and the merits of our case are such that we have good reason to believe that the decision of the Court of Appeals will be favorable to us.

Very truly yours,
The Westinghouse Air Brake Co.

Pittsburgh, Pa., Sept. 24, 1898.

The Accident at the New York and Ottawa R. R. Bridge.

Sir: In your interesting account of the failure of the New York & Ottawa R. R. bridge over the St. Lawrence River, it is not clearly stated as to what depth, if any, the crib foundation was sunk below the natural bed of the river. From the description I take it that the crib simply rested on the bed of clay and boulders. If this is true, it would seem a most serious fault of design for so important a structure. The sinking of the crib would increase the erosive effect of the current to some extent and would lead one to expect quite possibly, if not probably, what apparently did actually happen.

I do not believe, and think most engineers will agree with me, that any material other than solid rock is to be trusted for a foundation for a bridge pier in a river having so great a velocity of current, unless excavated so far below the natural bed of the stream, or so thoroughly protected by riprap or otherwise, as to make the undermining of the structure by the scouring action of the current practically impossible.

Yours respectfully,
E. W. Lewis.

Duluth, Minn., Sept. 20, 1898.

(Doubtless the engineers in charge of this piece of work considered that the bottom on which the crib rested was sufficiently stable to justify them in founding the crib directly upon it. They believed that the swift current of the river had in the course of centuries so scoured the bottom that no further erosion need be feared; and we are informed that the divers who went down inside the crib found the boulders on the bottom so firmly imbedded in the hard pan as to be very difficult of removal.

The protection of cribs by heavy rip-rap is always a good precaution, and the result in this case shows that it would have been wise to have made use of it; nevertheless, in fairness to those responsible for this structure, it should be said that rip-rap is frequently omitted on river bottoms of cobble-stones and boulders, where the engineer feels sure that the bottom will safely withstand the increased scour.—Ed.)

Differentiation in Professorships of Civil Engineering.

Sir: It is taken for granted that the title "Professor" will always be used to officially designate the heads of collegiate departments of civil engineering, although in social life it may be considered more desirable and refined to use the simple prefix "Mr." The indiscriminate prodigality manifested in appropriating the title (extending even to the signboard "Virgil Greene, Professor of whitewashing," swinging in a Southern alley, or "Professor Gray, dyer and cleaner," insinuating an academical interest in collegiate clothing) may approach the humiliating until one remembers that the man graces the title—the title does not make the man. After all, there is no other word that will so thoroughly designate and describe the professional duties under consideration.

The universal title of professor may, then, be considered as fixed. It may also be held as perfectly settled that American custom has become too well defined to consider favorably the system of many technical schools of continental Europe, which give to each member of its faculty simply the general title of professor without combining in that title the designation of his particular branch of instruction. Where a college charges one man with the responsibility of all the civil engineering instruction, there can be no question but that he should be the "Professor of Civil Engineering." This term in its fundamental meaning covers the whole field of engineering, except military, and therefore is most fitting. It is where the institution has grown to require a differentiation of instruction in civil engineering that confusion follows. Its cause is partly of classification and partly of administration; but the results, as exemplified by present practice, it may be hoped, are, in some respects, only tentative.

One college has a "Professor of Mathematics, Surveying and Astronomy," and at the same time a "Professor of Civil Engineering, Mining and Metallurgy,' and another has its "Professor of Mathematics and Geodesy," while still having its "Professor of Civil Engineering." Other institutions, while combining in a title courses more closely allied, still display a combination of branches not the most intimate in character, or a prolixity of terms quite subversive of a simple directness; as the "Professor of Civil Engineering in charge of Railroad Engineering and Geodesy." Several universities have a professor of civil engineering, and also professors of branches universally understood to be embraced by the general term of civil engineering. One college has its professor of civil engineering and associate professors of several of the subsidiary branches. Two universities have abandoned the title of professor of civil engineering, and have their professorships differentiated by titles distinguished by engineering designations which the term civil engineering broadly includes.

When there comes a marked increase in the instructional force, should one still be a professor of civil engineering with all the others subordinated, should the stronger men of this force be designated as professors of differentiated branches of civil engineering while still retaining this general professorship also, or should the latter proposition be adopted, but dropping the professorship of civil engineering?

The first mentioned plan is one adopted by British colleges, which usually have a professor of civil engineering, lecturers, demonstrators, assistants and instructors. Apart from the fact that this would involve a change in the prevailing American tendency and practice, there remains the situation that this plan would be hardly applicable to our colleges where the system of apprenticeship has no part in engineering education, and which are often situated in the smaller cities where eminent lecturers cannot be readily called upon as occasion demands. With us such men must be on the permanent staff of the institution if their services are secured; and in expanding to cover the ever broadening field of instruction and to keep pace with the demands of active engineering practice, men of recognized ability could not be expected to be made subordinates.

Moreover, there remains the most important consideration of all, the close touch that exists, the intimacy that must be fostered between engineering practice and engineering education. Civil engineers have differentiated as mechanical engineers, mine engineers and electrical engineers, so that now in America these last are rarely thought of as civil engineers; specialization has further given us railroad engineers, hydraulic engineers, sanitary engineers, bridge engineers, municipal engineers, geodetic engineers, topographical engineers, structural engineers and irrigation engineers—terms scarcely less fixed and characteristic than the previous ones; and it has coined and is adopting more or less well-known designations of similar style.

Profiting from this practice, mindful of the spirit of the usage of the universities, and aiming to secure titles that will be at once definite, distinctive and terse, it would seem no very difficult task to formulate a system applicable to any situation. The keynote to such a plan would be the use of the more general and inclusive designations where the number interested is few; the application of the more restricted and specific terms where those concerned are greater in number; and the passing from the former class to the latter with the growth of the institution by adopting the latter character of titles while abandoning the use of the former as circumstances permit.

Suggestive of development under this plan may be considered the adoption of the titles "Professor of Railroad Engineering" and "Professor of Municipal Engineering" where there are established two professorships. The former designation is already considerably used, but the merits of the latter term seem to have been overlooked by all but one of our universities. "Municipal Engineering" characterizes the title most fittingly, particularly where there are but two or three co-ordinated professorships; in style it is direct, simple and expressive; in significance it carries undoubted distinction; in scope it includes a large proportion of the civil engineering branches, while still being sufficiently elastic in application to embrace allied branches, or not, as circumstances make advisable; moreover, the term signalizes a line of labor that engages the attention and interest of a large number of our engineering graduates. In a large measure the same reasoning applies to the other title already mentioned, and together they would comfortably cover the whole field. Or, if three responsible heads were deemed advisable, the third appellation might, for similar reasons, be found in "Professor of Structural Engineering." Other professorships would find their appropriate designation in the list of engineering specialties already given or implied, always tending from the more inclusive terms to the more specific as the field expands. In special situations certain titles would naturally be adopted earlier than in the general case; as, in the arid states, the universities

would probably find the "Professor of Irrigation Engineering" of the first importance.

With co-ordinate professorships established to conform to the trend of engineering practice, with the covering of the field by these subsidiary titles, and with several correlated professors placed in responsible charge of the work, what reason remains for continuing the professorship of civil engineering? One who holds the latter title may readily object to assuming a less comprehensive one, or executive details may, in a certain case, interpose; but these will not permanently interfere with merging such a condition into the differentiating system of co-ordinate titles, and so giving free scope to a thorough education of the specializing engineer. As Mr. George S. Morison said in his Presidential address before the Am. Soc. C. E., 1895, "the civil engineer of the new epoch must be a specialist, . . . but his specialty must not be of a narrow kind; he must have that general knowledge and training that marks the liberally educated man."

The educational development of the immediate future involves specialization. Whether a thorough differentiation, meeting the needs and embodying the genius of the coming age will ultimately require (as sometimes with nations) the impulse of an all-embracing, supreme system, the future will disclose. If this occurs the professorship of civil engineering may well be reinstated, but with an enlarged significance. For it must follow differentiation to reunite all its branches, some of which are, in this country, already all but divorced, and others are in course of separation. Such an adjustment would mark the complete realization of the statement of the authority already quoted, that "it is a common error to think of civil engineering as a co-ordinate branch of a general profession with many other branches; to class it with mechanical engineering, with hydraulic engineering, with sanitary engineering, with mining engineering, with electrical engineering, or with any other specific branch. The name of every special branch of engineering has a distinctive meaning. . . . . Civil engineering, in its true meaning, embraces every special branch of engineering." However, our immediate concern is not affiliation, but differentiation.

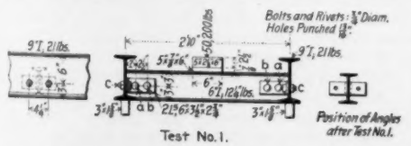
J. L. Van Ornum,
July, 1898.

Captain Third Regiment U. S. V. Engineers, Camp Hamilton, Lexington, Ky., Sept. 25, 1898.

Erroneous Data in Manufacturers' Hand-Books Concerning Structural Beam Connections.

Sir: The letter of May 6, 1898, addressed to you by Mr. Henry S. Prichard, of Trenton, N. J., is duly noted. In this letter Mr. Prichard criticises the data relating to beam connections in hand-books issued by the Cambria Iron Co. and others. In order to ascertain the actual facts in this case we had tests made of our standard beam connections with the results shown below: The details of the arrangement of the beams for test are shown on the accompanying sketches:

Test No. 1.—Connection angles were riveted to the 6-in. I-beams and bolted to the 9-in. beams with rough ⅝-in. bolts and the 6-in. I-beam was coped in our usual manner flush with the bottom of the 9-in. I-beams. The pressure of the testing machine was distributed over a space of 6 ins. at the middle of the 6-in. I-beam, as shown on sketch, and was applied by the downward pull of the moving head of the testing machine, which travels at the rate of about ¾-in. per minute. In this test the 9-in. I-beams were

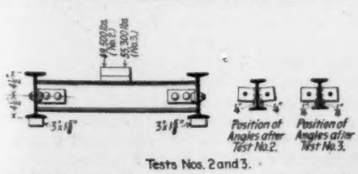


Test No.1.

Fig. 1.—Test of 6-in. I-Beam With Riveted Angle Connections Bolted to 9-in. I-Beam Girders and Coped to Fit Bottom Flange.

braced at both ends, as shown in the sketch. Pressure was applied up to 50,200 lbs., and the test was stopped as the 9-in. girder beams were bending outward and began to buckle. At the conclusion of the test the bolts, rivets and angles were found to be intact.

Test No. 2.—This test was arranged in a manner similar to that used in test No. 1, the only exception being that the 6-in. beam was not coped, and was bolted to the 9-in.

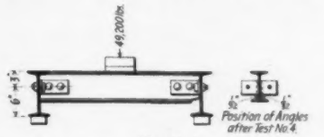


Tests Nos. 2 and 3.

Fig. 2.—Test of 6-in. I-Beam With Riveted Angle Connections Bolted to Middle of Web of 9-in. I-Beam Girders.

beams at the middle of their webs. At a pressure of 47,000 lbs. the connection angles began to spread and at 49,500 lbs. they had assumed the position shown in the sketch, when one bolt sheared at the connection with the 9-in. I-beam. The position which the angles assumed in this case was apparently due to the fact that the bolt holes in the connection angles were more than a quarter of an inch further apart than those in the 9-in. I-beam to which the angles were secured, and as the pressure was applied the slack was taken up with the result shown. This also caused a severe pressure to come upon the bolts, owing to the leverage or knuckle-joint action of the connection angles after they had assumed a position out of line. In this case the leg of the angle between the point of the connection to the 9-in. beam and the first rivet which secured it to the 6-in. beam was bent into a warped surface. After this test the rivets were intact.

Test No. 3.—This test was made on a 6-in. I-beam of same construction as that used in test No. 2, with the exception that the 9-in. I-beams were not braced together at either end. The ultimate strength developed was 55,300 lbs. when the 6-in. I-beam bent and buckled. The test was continued until the load dropped to 40,000 lbs., when the I-beam was very badly distorted. At the end of the test the connection angles were spread at their lower edge about 1-16-in., as shown on the sketch, but the rivets were intact. The four connection bolts were slightly distorted by the shearing strain due to the spreading of the connection angles, but they did not shear.



Test No.4.

Fig. 3.—Test of 6-in. I-Beam With Riveted Angle Connections Bolted to 9-in. I-Beam Girders and Coped to Fit Top Flange.

Test No. 4.—This test was made on a 6-in. 12¼-lb. I-beam, which connected to the 9-in. I-beam and coped flush on top. One of the ends of the 6-in. beam was also coped on the bottom, as shown in the sketch. In this test

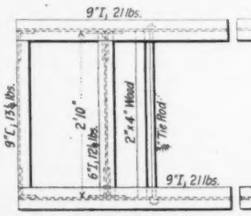


Fig. 4.—Plan Showing Arrangement Used for Making Tests Nos. 1 and 2.

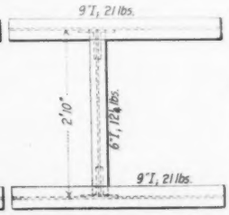


Fig. 5.—Plan Showing Arrangement Used for Making Tests Nos. 3 and 4.

the 6-in. I-beams bent and buckled in the center at a maximum load of 49,200 lbs., and the connection angles did not bend away from the web of the beam more than 1-32-in. In this test also the rivets were intact, but the bolts were slightly distorted as in test No. 3.

The material of which the beams and connections were composed was ordinary medium Bessemer steel taken from stock without any selection, and the workmanship was of the ordinary commercial character.

Although Mr. Prichard's remarks relate to the strength of the beam connection under uniform load the arrangement of testing machine did not permit of the introduction of a load of this character, and in consequence the tests were made with a central load on a beam of about half the length of that to which Mr. Prichard refers, in order that the conditions might be similar as nearly as possible under these circumstances.

As stated on page 39 of the book entitled "Cambria Steel," the minimum span for which standard connection angles may be safely used with a 6-in. 12¼-lb. I-beam uniformly loaded to its full capacity in accordance with table of safe loads corresponding to a fiber stress of 16,000 lbs. per sq. in. is 5.7 ft., and the uniform load corresponding to this length is 13,600 lbs., as shown by table on page 74. The average ultimate load on the beams as shown in tests 2, 3 and 4 is 51,333 lbs., and these loads were approximately central, and if we assume a safety factor of four, this practically corresponds with the safe load, which is 13,600 lbs., as stated in the Cambria book. The load in test No. 1 did not come upon the connection angles, but was transmitted to the flange of the 9-in. beam. It should also be considered in all of these tests, with the exception of No. 1, that the full capacity of the connection was not reached, as the beam failed by bending and buckling without destroying the connection.

If we should carry Mr. Prichard's statements to their logical conclusion in view of the figures which he presents and the above tests, the shear on the rivet would be about 268,000 lbs. per sq. in., notwithstanding which the facts are that they did not fail, thus showing the entire fallacy of his reasoning, as no rivet could be expected to withstand any such stress.

The tests which were made on the 6-in. 12¼-lb. I-beams show that the strength of the connection for this size, as stated in the Cambria tables, is correct, but at the same time the strength of this same connection when used on heavier sections of 6-in. beams might not be sufficient for the short spans stated in the tables. Very short spans are not ordinarily used in building work, and if used are not likely to be loaded to the capacity of the beams. For the reason, however, that none of the tests (with the exception of test No. 2, which was not representative on account of the differences in spacing of the bolt holes), developed the strength of the connection, but bent and buckled the beams themselves, the actual ultimate strength of the connection was not fully demonstrated. The statements made by Mr. Prichard relating to the connections for 6-in. 12¼-lb. I-beams are fully disproved by the actual results of our tests. We must thank Mr. Prichard for giving us the opportunity of demonstrating the correctness of our figures with regard to the particular connection in question.

Yours truly, Geo. E. Thackray.
Johnstown, Pa., June 3, 1898.

(When we received Mr. Thackray's letter, Mr. Prichard had already notified us that he proposed to reply to Mr. Christie's letter in our issue of July 21. In order that the whole remaining correspondence might be presented to our readers together, therefore, we furnished a proof of Mr. Thackray's letter to Mr. Prichard, enabling him to reply to both communications in one letter.—Ed.)

Sir: The replies of Mr. Christie, writing for the A. & P. Roberts Co., and Mr. Thackray, writing for the Cambria Iron Co., to my criticism of the table giving the strength claimed for standard beam connections (Eng. News, July 21), leaves the discussion of the point at issue in a condition which makes further discussion and investigation desirable.

As a preliminary, it is well to state the requirements for safe connections. At 16,000 lbs. extreme fiber stress, a steel beam has a factor of safety of about 2, as regards the beginning of failure, and about 4, as regards complete failure; supposing it to fail by bending. The factor of safety required for the connections should be equal to or greater than that required for the beams, both as regards the beginning of failure and complete failure. A table giving the strength of standard connections should state as the strength of each connection an amount no greater than should be used under the most unfavorable conditions to which the table can be reasonably understood to apply from a consideration of its title and the descriptive matter accompanying it.

The table criticised is based on uniformly distributed loads; but the tests of 6-in. and 8-in. beams, quoted by Mr. Christie, were made with concentrated loads applied at the middle of each span, the 6-in. beams being rolled-up sections having about 50% greater rivet bearing than the minimum size to which the table applies, and the 8-in. beams being of shorter span than called for in the table. The loads were, therefore, less than half what should have been used to test the accuracy of the table and the rule by which it was calculated.

In the tests made by both the A. & P. Roberts Co. and the Cambria Iron Co. the connection angles were riveted to the webs of the beams tested. This corresponds with the illustrations in the Roberts' hand-book, as they show the connections riveted and make no mention of bolts. In the Cambria book, however, and in the books of the other companies referred to in the criticism, the connections are shown with holes which are stated to be for either bolts or rivets. As bolts are generally conceded to be weaker than rivets, they should have been used by the Cambria Iron Co. in testing the accuracy of their table and the rule by which it is calculated.

Neither the A. & P. Roberts Co. nor the Cambria Iron Co., in the published reports of their tests, have noted the points at which failure of the connections began, and consequently they do not give full data from which to determine the safe loads. The data published, however, are sufficient to show a marked discrepancy between the results obtained and the amounts given as the safe loads by the method advocated in the criticism. In accounting for this discrepancy, Mr. Christie takes no exception to the reasoning employed in the criticism, but attributes it to the neglect of "two elements of resistance" in the premises on which the reasoning is based. Mr. Thackray, on the other hand, takes no exception to the premises in which three elements of resistance are neglected; to wit: the frictional resistance from the grip of the rivets, the partial fixedness of the ends, and another element hereinafter described, but claims that the discrepancy shows the entire fallacy of the reasoning. In view of this difference of opinion between the author's critics and the insufficiency of the published reports of the tests which they quote, some additional tests seemed desirable and have been made.

Six beams were tested, the ends in all cases being simply supported. The sizes and arrangement of the beams and connections are illustrated in the accompanying cuts. The outstanding legs of the connecting angles were riveted to the flat connecting each pair in all cases except No. 6, in which they were bolted. The connection angles were 6 × 4 × 7-16 ins. for Cases 1, 2 and 6, and 6 × 6 × 7-16 ins. for Cases 3, 4 and 5. The beams were 6-in., 12¼ lbs. per ft. with webs 0.23-in. thick for Cases 1, 2, 5 and 6, and were 6-in., 17¼ lbs. per ft. with webs 0.46-in. thick for Cases 3 and 4.

In Case 1 the connection angles were bolted to the beam with rough bolts, forced to a bearing before the test, and the nuts were screwed up to a gentle touch only. In Cases 2 and 4 the connection angles were riveted to the beams. In

Case 3 the connection angles were bolted to the beam with turned bolts, which fitted the holes, and the nuts were screwed up to a gentle touch only. In Case 5 the connection angles were riveted to the beam, but the holes in the beam were made ⅛-in. larger than the diameter of the rivets to prevent the rivets from getting any bearing on the beam, the object being to test the frictional resistance from the clamping power of the rivets. In case 6 the connection angles were bolted to the beam with rough bolts

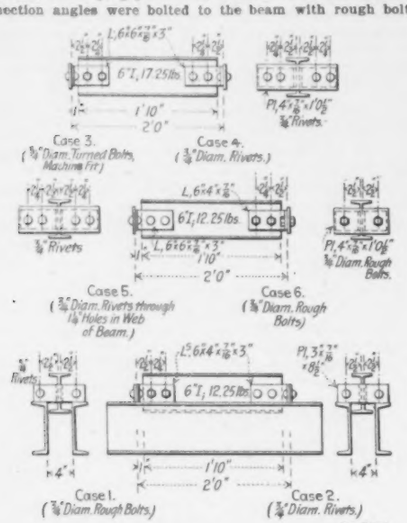


Fig. 1.—Diagrams Showing Sizes and Arrangement of Beams and Connections Tested by Mr. Henry S. Prichard, New Jersey Steel & Iron Co.

forced to a bearing before the test, and the nuts were screwed up tight so as to give all the frictional resistance practicable. The rivets and bolts were all ⅞-in. in diameter, the rivets were machine driven, and the holes were punched 13-16-in. diameter, except those for the turned bolts and those in the web of the beam in Case 5.

It was intended to test the connections only and not the beams, and to insure the beam from failing, distributing flats were placed between the top flange and the pressure edge of the testing machine. In Cases 1 and 2 the flats were not added till the beam began to fail.

The results of the tests are given in the table below, to which is added a comparison between the calculated safe loads for the connections and those indicated by each test separately considered.

In calculating the safe loads by the usual method (that on which the table criticised is based), the bearing value for both rivets and bolts was taken at 20,000 lbs. per sq. in. as stated in the tables criticised. In calculating by the writer's method, the bearing for bolts was taken at 18,000 lbs. per sq. in. and for rivets 21,600 lbs. per sq. in., to agree with the article on beam connections in Engineering News of May 16, 1895. In obtaining the safe load indicated by each test a factor of 2 was used with regard to the beginning of failure, and of 4 with regard to complete failure.

The point at which the connections began preceptibly to rotate with reference to the web of the beam was taken as the beginning of failure. In Case 5 it was possible to obtain this point easily and accurately because after the point was reached the pressure on the machine remained stationary for a few moments. In the other cases, however, it is probable that the results are a little high, as it is difficult to perceive by simple observation the very slight movement which accompanies the beginning of the crushing of the bearing surfaces.

In arranging for the tests the beams were first supported at the ends by resting the flats connecting the outstanding legs of the connection angles on a pair of channels. After the connection at one end of a beam had failed, a support was placed under the beam at that end.

The load was applied midway between supports in each case, and one-half the pressure indicated by the machine was taken as the load on a connection. In each case the connection angles rotated about an axis perpendicular to the web of the beam, as shown in the photograph, bringing pressures in opposite directions on the two bolts or rivets connecting the clips to the beam. That the pressure on the bolt or rivet nearest to the edge of the beam was much greater than on the other one was shown by the amount the holes enlarged and by the shearing of the bolts and rivets. The connection angles at each end of each beam also rotated in a plane perpendicular to the web of the beam, and in opposite directions, as shown in the photograph, so that

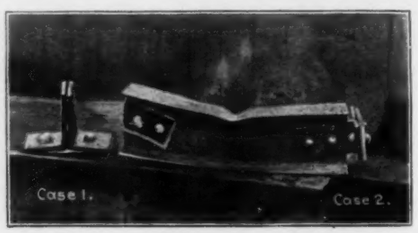


Fig. 2.—View of Angle Connections Showing Manner of Toggle Joint Action.

their tops approached each other, producing a toggle joint action, and firmly clamped the beam. The effect of this was to weaken the connection of the outstanding legs to the flat and strengthen the connection to the web of the beam. The clamping pressure developed was in some cases so great that the webs of the beams were crushed a full 1-32-in., and a bearing thus secured at the upper edges of the clips. Mr. Thackray mentions a similar "knuckle-joint action," as he terms it, in one of his experiments, but he mentions it only as a source of weakness. The strength added to the connection to the web of the beam by this toggle-joint action was not mentioned by either Mr. Christie or Mr. Thackray, and was neglected in the writer's theory, but it appears to have been the chief element in causing the high ultimate strength which most of the connections developed. It is probable that it also added considerable strength to some of the connections before failure began. This is indicated by the fact that in Case 2, in which the chance for toggle-joint action was greater and the bearing surface of the rivets less than in Case 4, the point at which failure began was higher than in Case 4. The writer's theory also neglected the partial fixedness of the ends and the frictional resistance from the clamping effect of the rivets and bolts. If the ends were partially fixed it would have some indirect as well as direct effect on the strength of the connections by modifying the toggle-joint action, but the writer's experiments have not covered this point. The frictional resistance from the clamping power of the rivets and bolts amounted to 2,000 lbs. in Case 5. In Case 4, by comparison with Case 3, in which the nuts simply touched, it was probably about 3,000 lbs., and in Case 6, by comparison with Case 1, about 2,000 lbs.

That the loads at which failure commenced in Cases 1 and 6 were small as compared with the other cases, is probably due to the fact that the bolts did not fill the holes and consequently had very little bearing at the start (theoretically only a line of bearing). As the bolts would get their full bearing before failure had progressed very far, the safe load indicated by the tests can hardly be regarded as a fair criterion. That Case 4, in which rivets were used to connect the clips to the beam, developed so much greater ultimate strength than Case 3, in which turned bolts were used, was due partly to the fact that the rivets were initially tight, while the bolts were not, partly to the fact that the rivets were steel while the bolts were iron, and partly to the fact that the greater strength of the rivets made them last longer and thus enabled a greater toggle action to be developed.

The most seemingly astonishing fact was that in Case 1 the ultimate strength was much greater than in Case 3, notwithstanding the fact that in Case 1 rough bolts were used, against turned bolts in Case 3, fewer rivets connected the outstanding legs of the clips to the flats, and the bearing surface of the bolts was 50% less. This fact is probably explained by the greater toggle-joint action permitted by the construction in Case 1.

Mr. Christie's, Mr. Thackray's and the writer's experiments, considered together, show conclusively that the strength of a connection cannot always be obtained by simply multiplying the nominal strength of one rivet (or bolt) by the number of rivets in the connection, as the authors of the table criticised assumed, and that the strength of a connection depends not only on the bearing and shearing strength of the rivets (or bolts), but also on a number of other elements. Whether or not it is good practice to rely at all on these other elements of strength is an open question. The authors of the table criticised do not appear to have thought that it was, because in the descriptive matter accompanying the table they claim that it is based on the bearing and shearing values of the rivets. If it is proper to rely on these other elements of strength, then the writer's theory gives results which in some cases err considerably on the side of safety. On the other hand, even if these elements of strength are relied on, the method of calculation on which the table criticised is founded gives results which in some cases are dangerously high.

Respectfully,
Henry S. Prichard.

Trenton, N. J., Sept. 3, 1898.

Results of Tests for Strength of Standard Beam Connections.

Case.	Load at the beginning of failure, lbs.	Ultimate load, lbs.	Safe load—Indicated by test, lbs.	Safe load—Calculated by—Usual method, lbs.	Safe load—Calculated by—Writer's method, lbs.	Remarks.
1.	2,000	24,900	1,000	6,900	1,470	Beam split from hole "a" to edge at 22,800 lbs., after ultimate had been reached.
2.	13,000	.....	6,500	6,900	1,765	Did not fail under load of 24,900 lbs.
3.	9,500	17,790	4,450	13,800	2,940	At 17,790 lbs. bolt "a" sheared off.
4.	12,500	40,310	6,250	13,800	3,530	At 35,000 lbs. cracking noise; cause not discovered. At 40,310 lbs. rivet "a" sheared off.
5.	2,000	.....	1,000	.....	.....	Frictional resistance test, carried to slipping point only.
6.	4,000	24,700	2,000	6,900	1,470	At 22,000 lbs. one clip began to crack; at 24,700 lbs. bolt "a" sheared off.

Notes and Queries.

In our issue of Sept. 1, p. 143, we published an abstract of a paper read before the American Association for the Advancement of Science, by Prof. L. G. Carpenter, of Fort Collins, Colo., on "The Energy received from the Sun." In this abstract the energy was given as "½ to ¼-HP. per sq. yd." These figures should have been 0.5 to 1.4 HP. The statement of the energy in calories (7 to 17) in the abstract was correct.

In the article on "Metal Trucks for Freight Cars," in our issue of Sept. 15, it was stated in reference to the Cloud truck that about 2,600 are now in use. The Cloud Steel Truck Co. now informs us that since furnishing us the figures used in the preparation of that article they have done a large amount of business. Up to the present time they have sold some 5,000 Cloud truck frames and 15,000 of the Bettendorf I-beam steel bolsters.

D. B. McK. asks if a beam or column whose cross-section is an equilateral triangle can be strengthened by cutting off a certain portion of each of the three corners? He says that the strength varies as $\frac{I}{c}$, (I) being the moment of inertia and (c) the distance of the farthest fiber from the neutral axis, and that while (I) is reduced by trimming the corners, (c) is diminished more than (I), and therefore the beam is really strengthened. This is correct, according to the accepted theory of flexure, and on page 180, of Wood's "Resistance of Materials" (second edition), will be found a solution of the problem. In the case of a triangular section, if one of the corners be taken off for 0.13 of its depth, the remaining trapezoidal beam will be 1.091 times as strong as the triangular beam. In other words, there will be a gain of 9%. It is also true that the other corners can be trimmed off slightly without causing any appreciable weakening.

RAILWAY CONSTRUCTION IN DISTRICTS SUBJECT TO INUNDATION.

In describing the new railways to be built in the province of Shansi, China, in our issue of March 31, we mentioned that the crossing of the wide alluvial plains bordering upon the rivers presents a somewhat difficult problem, as these plains are subject to inundation during the rainy season, when the rivers overflow their banks. To build a high-level line would be costly, especially in view of the amount of waterway to be provided by bridges or trestles, and it is intended, therefore, to build a low-level line which will be covered during the floods, but will be left practically uninjured when the water subsides.

This same problem has been encountered in Australia, more especially in Queensland, where the economic value of the low-level system, in spite of a short interruption to traffic, appears to have been abundantly proved. In an interesting little book on "Pioneer Railways for Queensland," by Mr. George Phillips, a civil engineer who has had extensive railway experience in that colony, this particular subject is discussed, and the advantages of the low-level system of construction in that colony are shown by practical experience. The illustrations show some of the low-level river crossings during and after the floods, the latter showing that the small short bridges are practically uninjured, and only blocked by dirt and drift which can easily be cleared away. On the other hand, the views show that longer and more substantial bridges built on high-level lines in the same district have been practically wrecked, some of the costly metal spans having been carried away. The low-level system requires a minimum amount of expense for general construction and for bridging, while the bridges can usually be renewed promptly and at small expense if they should be washed out. The high-level system involves more expense in construction for embankments and waterways, while the bridges are larger and considerably more expensive, involving a much greater expenditure of money and time in

renewal. With the low-level bridges, the higher the flood the less is the danger of damage by drift, etc., but with high-level bridges any rise in the water increases the danger.

An illustration of this is afforded by the experience with two bridges in Queensland. It is stated that the low-level deck bridge over the Burdekin River withstood several floods, the maximum depth of water being 50 ft. above the floor. The Logan River bridge, with two piers and three metal through spans, was built with its rail level 6 ft. above the level of the highest recorded flood, but in 1887 the flood rose 11 ft. above the rail level and the piers and spans were swept away.

We have had occasion before to point out the expense which has attended the endeavors of European engineers to introduce European methods of practice in the colonies, and their failure fully to recognize economic considerations or the influence of local conditions. This conservatism and adherence to old-world customs naturally led to considerable opposition to Mr. Phillips' plans for low-level railways, economical in cost, but the practical results appear to have fully substantiated his claims. For about 90 miles the Normanton & Croydon Railway crosses black-soil plains, and here Mr. Phillips used timber and steel-trough ties, bedded to half their depth in the soil and with earth filled in round the ends. After the first heavy rains the road settled down uniformly, leaving the surface slightly higher than that of the surrounding country, but not enough to interfere with the natural drainage. After a flood the line was easily and quickly put in condition for traffic, even when the ground was for weeks too wet and boggy for wagon traffic. Subsequent attempts at improvement by other engineers who failed to grasp the principles of construction of this line, had unsatisfactory results. It was thought that even a pioneer line could not be permitted to exist on the surface of the ground, and, therefore, the track was raised above the ground level, with the result that the floods turned the dirt ballast into mud which washed out and left the line in bad condition. The remedy then suggested was to use stone ballast, which was not obtainable for a long distance. The Railway Commissioners feared that it would be only a "fine-weather" line, and that the cost of maintenance would be higher than for a road "properly ballasted and drained," but, as a matter of fact, the low cost of construction more than compensated for the slight interruptions to traffic, while the cost of maintenance was very much less than the average for the Queensland Government Railways, although wages were higher on this line.

Mr. Phillips quotes from the article on "English Railway Practice in India and the Colonies," in our issue of Aug. 4, 1892, and we give below some extracts from his discussion of the question of low-level lines:

As a rule, natural drainage is only applicable to pioneer railways, and chiefly in even country within tropical or subtropical regions, where its adoption in lieu of the artificial method means all the difference between a high cost and a low cost road.

In mountainous country there is practically no choice, and sufficient provision must be made for artificial drainage below the level of formation, but in uneven country very considerable economies can be safely practised by adopting in a modified form the principle of natural drainage at the crossings of the larger watercourses. The instances in which a high-level bridge will practically cost no more than a low-level bridge at the same place are comparatively rare, and only occur where the whole of the flood water is confined to one well-defined channel with banks of the same or very nearly the same height. Very frequently the broken portion of the channel of a river can be spanned in a few hundred feet, whereas in times of extreme flood the water may cover low-lying land on one or both sides of the main channel to a width of thousands of feet, or even of several miles. Now, these are precisely the places where a large expenditure may be incurred under the high-level or artificial system of drainage, or great economies may be effected under the low-level system, and it should be remembered that in the case of pioneer railways the value of the traffic to be carried in any one year will not be increased under the first system, nor diminished under the second system.

The necessity for, or the adoption of, artificial drainage in even and uneven country, rules to a very great degree the selection of route, and determines the extent and cost of the work. No one who has not been professionally engaged in the selection of railway routes in new, uncharted, and thinly peopled countries, can form any idea of the extent to which the question of artificial drainage dominates almost every other consideration. The crossing of and the providing passage for, or the avoidance of water, are very frequently the chief items of expense, more especially in even country, where the surface of the ground offers every natural facility for the laying down of inexpensive pioneer railways, the cost of which need not greatly exceed the value of the rails, fastenings, and sleepers; but the difficulty of providing artificial drainage below the level of formation stands like a lion in the path of the engineer, who considers that artificial drainage is a necessity.

Under the European, or high-level system, it not infrequently necessitates great detours to avoid low-lying and flooded areas, thus thrusting the lines back into broken and hilly country, when much easier gradients could often be secured at far less cost over the flooded flats, but the fear of injury to embankment or occasional delay in the running of trains is ever active with the engineer who is wedded to the high-level system.

It seems almost incredible that while settlers may dwell, cultivate, and carry their produce to market on even country, which is occasionally inundated, it is deemed by some engineers that to lay inexpensive railways on the surface of such country, is so unprofessional as to be almost immoral, so that the very munificence of nature is regarded as sufficient reason for depriving the settlers of those modern facilities which alone can enable them to turn the bounty of nature to the fullest account.

Until a more common sense system be generally adopted, the extension of railways in such countries as China, Africa, South America and Australia, will progress but slowly and intermittently.

The European, or high-level method of building railways prescribes that all water crossing the route of a railway must be provided passage below formation. This may not be so serious a matter in Europe, where the rainfall is usually well distributed throughout the year, and in any case the extent of traffic to be served justifies expensive and high-class lines of communication.

In the tropics, and regions adjacent thereto, the rainfall is usually confined to a period of a few weeks at certain seasons of the year, and the body of water to be provided passage for under the high-level system is sometimes enormous in volume and extent.

In Australia, there are many rivers which occasionally overflow the banks of their usual channels, and cover areas of adjacent country to a width of from 1 to 20, and even 30 miles. These exceptional floods are not frequent, and in any given locality their periodicity is so uncertain that intervals of 5, 10, 15, and 20 years may, and sometimes do, elapse between them.

In passing, I may say that while I have known several high-level bridges to be destroyed by floods, I do not know an instance in which a low-level railway bridge has been seriously injured from the same cause, although numbers of such bridges have been submerged time and again to depths ranging up to 50 ft. The reason for this immunity is that logs, trees, and floating debris are only brought down in any great quantity whilst floods are at or near their full height, so that the floating material is safely carried over the low-level bridges; on the other hand, should a flood rise a few feet higher than usual, or than is anticipated, the debris is apt to lodge against the girders of high-level bridges, and thus subject them to severe lateral stresses.

I have not enjoyed the privilege of visiting China, but I have a theory that the conservative Chinese will not favor the construction of railways with high embankments over the even cultivable plains adjacent to their great river systems, as such embankments would necessarily derange their complicated system of boundary ditches by gathering the drainage of many ditches to a focus, and discharging the accumulated water at new and unaccustomed points. I feel confident that this is a question which engineers constructing railways in China would do well to take into serious consideration.

There are many places in Australia where the raising of an embankment five or six feet in height across long stretches of even country, through interference with natural drainage, result in serious loss to the occupants of the adjacent country, whether they be engaged in pastoral or agricultural pursuits. I have taken sections across 15 or 20 miles of plains, bounded on either side by rivers, where the difference in level was very trifling throughout the entire length of the section, and it is not difficult to conceive that what would only be an inconvenience when the plains were covered with a few inches of surface water, might, under the retarding influence of a railway embankment, become a serious source of loss where sheep are pastured or valuable crops are grown.

As an illustration, take the case of the railway from Sydney to the town of Bourke, in New South Wales. For several hundred miles this railway traverses even country very similar to that on the lower Flinders River in North Queensland; for the last 13 miles before entering Bourke the railway is within the high flood area of the Darling River, and is constructed on the high-level principle, with an embankment some 5 or 6 ft. in height, pierced by many flood openings. It should be observed that the railway does not cross the river, but merely intrudes upon the flooded area.

In April, 1890, the last 13 miles were washed away during a high flood, so that communication with the town could only be maintained by boats. This portion of the railway probably cost $40,000 per mile, but I have no hesitation in saying that a surface line, costing not more than $10,000 per mile, would have proved equally serviceable, and would not have needed reconstruction after the flood subsided. In addition to this, it is evident that the embankment (despite the numerous flood openings) must to some extent have retarded the escape of the flood water, and thus have caused it to rise to a greater height in the town of Bourke, the inhabitants of which ineffectually attempted to protect their homes by means of a rampart of earth encircling the town and abutting in two places upon the railway embankment.

When the railway engineer comes to deal with even country, more especially if he has been chiefly accustomed to construction in uneven country (as is almost invariably the case with European engineers), he is a good deal puzzled as to the best methods of procedure. If he consults the standard works on civil engineering he will learn that the approved method of crossing a great plain is to throw up an embankment from side-cuttings, which are ultimately intended to serve as ditches. Probably his author makes no comment upon the necessity for cross drainage through the embankment, or, even so, gives no clue as to the amount to be provided.

The engineer looks with anxious eye upon the vast expanse of plain, which his levels tell him rises or falls on either side of the proposed line of railway, and he commences to wonder what the effect will be when those plains are submerged, 1, 2 or 3 ft. deep with water, and he realizes that the higher the embankment the deeper the accumulated water will be, and the greater the destruction if it should overflow the embankment.

Evidently there are only two courses that can be wisely adopted. The first, and the most usual method, is to throw up an embankment of sufficient height, and at the same time provide sufficient openings to carry off the intercepted water before it has time to rise above the level of the formation. The second method (as advocated by me for pioneer railways in Queensland), is to keep the line right down on the surface and permit the water to follow the lines of natural drainage even if those lines take the water over and across the railway. An intermediate course is sometimes pursued by throwing up a low embankment from soil obtained from side ditches, supplemented by a few box-drains put in very much at haphazard. The fallacy of this method is generally demonstrated upon the first heavy rainfall sufficient to scour out the shallow formation and ballast, thus leaving the road in an impassable or dangerous condition.

The first, or high-level method, if carried out in a scientific manner, entails a great deal of trouble and additional expense in the survey, as the areas to be drained must be ascertained, with approximate accuracy at all events, whilst the water sheds of even country cannot be easily defined, and they are often very remote from the railway.

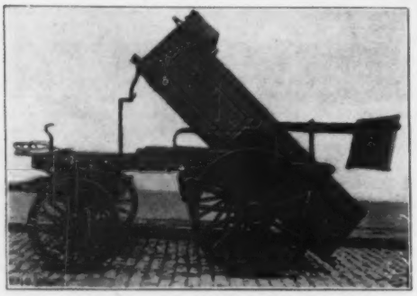
The following is an extract from "Engineering," London, Nov. 22, 1889:

From Amballa to the Sutlej River the line crosses an immense number of waterways, many of which are the so-called lost rivers, whose water ultimately disappear in the great Indian Desert. For some reason that is not quite evident, the former effluents of the Indus system that debouch from the hills to the eastward, do not now carry anything like the steady quantities of water they formerly did—although at times, with heavy rains in the foothills, they still come down in tremendous spates that last but a few hours, and bring with them, as all hill torrents do, immense volumes of silt. At some point or other in the course of each such waterway a bar has silted up the defined channel, and just above it the water of a spate fans out and covers a wide tract of country. While it lasts this is a very profitable form of natural irrigation. But, unfortunately, each spate brings with it a share of debritus, and as it cannot force this over the bar, it necessarily deposits it higher up the channel, and thus the bar, which forms the root of the fan, is perpetually retreating upstream and nearer to the hills. Of late years the consequences of this action have been very disastrous for the railway line between the Jumna and the Sutlej, for the rivers, as they once were, with fairly defined and deep channels that were bridged 25 years ago with perfect success, now "spill" or fan out their waters over the lands above the line, and for several years past, in spite of the addition of immense lengths of flood openings, each recurring July and August has seen the railway breached and communication jeopardized, if not entirely cut off. As the cheapest and best way out of this class of catastrophe, Col. Conway Gordon, the present Director-General of Railways in India, has proposed to lower the level of the rails for, perhaps, miles together, till flush with the natural surface of the absurdly slight depressions that scarcely differentiate one "spill" from another.

A NEW DUMPING WAGON FOR HANDLING GARBAGE AND OTHER MATERIAL.

Two of the essentials of a good dumping wagon are that the load be well distributed over front and rear wheels, so as to haul easily, and that the dumping mechanism be strong and simple These qualities are both claimed for the wagon illustrated herewith. The load is carried well forward, while in transit, and is shifted backwards, when it is desired to dump, on rollers, running in guides, as shown in the view. The trunnion-plate is fastened to the body of the cart. The rolling motion is secured by pushing or pulling, or by means of the lever shown in the view. The end gate is lifted automatically,

as shown. The wagons are furnished with metal covers, if desired, and the box is of steel. Where desired, an inclined fixed end is substituted for



A Dumping Wagon for Garbage or Other Material, with Automatic Tail-Board.

William Beckert, Manufacturer, Allegheny, Pa.

the tail board, which some would prefer where garbage and some other materials are being hauled. The wagons are made in various sizes by Wm. Becker, 340 Ohio St., Allegheny, Pa.

DISTRIBUTING MEAT BY ELECTRIC CARS IN BUENOS AYRES.

In Buenos Ayres, Argentina, the government owns and operates the abattoirs, and no slaughtering of cattle is permitted elsewhere; the purpose being to permit government inspection of all animals used for food, and to prevent the use or export of unhealthful meats. The abattoirs are located 14 miles from the city, and provide meat both for local use and for export in cold storage.

Two styles of car are used; a motor-car and a trailer, the latter may also be attached to a passenger or ordinary motor-car. These trailer-cars weigh 6,820 lbs.; and when loaded with three full boxes they weigh 23,250 lbs. The city has ordered 75 cars of this class. Of motor-cars there will be twenty mounted on 21 E trucks and weighing, with trucks, 8,600 lbs. In this type the center box is stationary and the top supports the trolley board and pole.

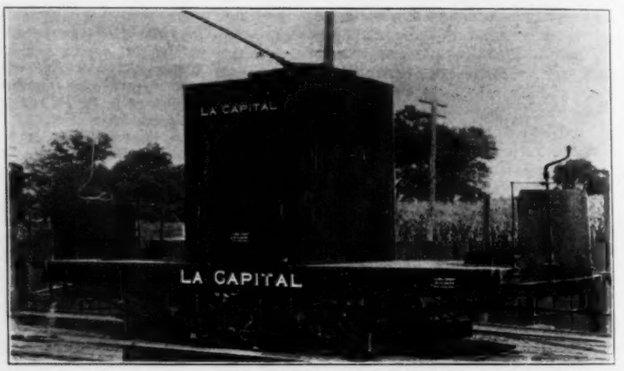
The meat boxes are 5 ft. 11 ins. square outside and 7 ft. 3 ins. high. They have double sides, are lined with zinc, and are provided with slat ventilators in the two sides and in the door. The door lifts upward; and to economize space in front, the part below the door lifts out. Inside the boxes have pipe racks in the center and along the sides and stationary racks in the roof; all of these are provided with sliding hooks for meat. As shown each outside corner of the box is fitted with a heavy iron strap terminating in a strong eye, by means of which the boxes are handled. The boxes carry 6,000 lbs. of meat, and weigh when filled 7,750 lbs.

The advantage of such a systematic handling and distribution of dressed meats for the supply of a city will be obvious. Those who will later have the charge of administering city governments in our new tropical possessions may do well to take a leaf from South American practice.

A NEW HIGH DUTY RECORD FOR PUMPING ENGINES.

We have received a copy of a report made by Prof. W. F. M. Goss, M. Am. Soc. C. E., of Purdue University, of a test of a 20,000,000-gallon triple expansion pumping engine, built by the Snow Steam Pump Works, Buffalo, N. Y., for the

View of Trailer.



View of Motor Car.

DISTRIBUTING MEAT BY ELECTRIC CARS IN BUENOS AYRES.

The dressed meat is distributed to markets and butcher shops by special cars operated on a railway connecting the city and the abattoirs. In 1885 the J. G. Brill Co., of Philadelphia, built special meat cars for Buenos Ayres, Santiago, Montevideo and other South American cities. These cars were hauled by horses and were of necessity small and carried light loads. The carcasses were carried to the cars; hung up inside; hauled to the city, and at any point where meat was wanted the quarters of meat were taken down and carried into the market. This plan was laborious and slow, and involved considerable exposure of the meat to heat and dust.

The introduction of electric traction greatly improved the previous facilities for handling meat; and the illustration here given shows the latest cars built for this purpose by the J. G. Brill Co

By this arrangement the meat is taken from the refrigerators and placed in specially made boxes. These are placed by a crane upon a flat-car, which is hauled by a motor-car directly to the markets without exposure. Upon their arrival at their destination a powerful crane, at the curb line, lifts each box from the trailer and deposits it upon a strong three-wheeled truck, which takes it directly into the ice-box; the trailer then goes on to other points of distribution.

Indianapolis Water Co., under the superintendence of Mr. L. K. Davis, consulting engineer, 220 Broadway, New York city. The results give the remarkable figures of 150.1 million foot pounds of work per million British thermal units, and 11.26 lbs. of dry steam per I. HP. per hour. This duty figure, we believe, is the highest ever recorded on the heat unit basis, although the steam consumption per I. HP. per hour is not quite so low as that obtained by the Leavitt triple expansion engine at Chestnut Hill station, Boston, viz., 11.2 lbs. (Peabody's Thermodynamics, 4th ed., p. 355). That the figures are open to some question is apparent from the comments on them made by Prof. Goss himself, which we quote below, and it is to be hoped that another test of the engine may ere long be made, in which the water consumption may be measured by the feed water used in the boiler as well as by the water discharged from the hot well, the latter method being the only one used in Prof. Goss's test.

The test was made on July 8 after a preliminary run to give practice to the observers had been made the day before. The engine was in charge of Mr. E. C. Sornberger, representing the Snow Steam Pump Works, and the Indianapolis Water Co. was represented by Mr. John Rail. Some of Prof. Goss's comments on the test given in his report to Mr. F. A. W. Davis, vice-president of the Water Co., are as follows:

Viewed as a piece of experimental work, the test was a most satisfactory one. The methods followed were carefully chosen, the apparatus employed was known to have been in excellent order, the desired conditions of running were well maintained, observers were employed in such number as to allow the work of each one to be easily performed in the time assigned, all observers were skilled engineers, and they were especially drilled by a trial run. It would appear, therefore, that the results as presented, possess a degree of accuracy which is fully equal to that usually attained in the course of such work.

The duty disclosed by the data exceeds by a liberal margin that obtained in any test, the results of which have thus far been published. It justifies the conclusion that no engine exists which can equal the performance of the engine tested. The famous Milwaukee engine, known to engineers the world over, gave a duty of 127.1 million which is to be compared with the 150.1 million delivered by the Indianapolis engine.

The plan of the tests was not sufficiently extensive to permit a complete analysis of all the conditions affecting the work of the engine, but it would appear that the high performance is due to good work by every part of the machine. Not only is the cylinder economy exceptionally fine but the frictional losses are extremely low.

Leakage.—Very careful tests were made by the undersigned, and later by Mr. Rail, to determine the amount of water leaking past valves and plungers. It was found that leakages from all sources combined amounted to but a few thousandths of one per cent. of the water pumped, justifying the conclusion that for all purposes, either practical or theoretical, the pump is tight. The significance of this statement will be better appreciated when it is considered that the pump contains 540 suction-valves and 540 delivery valves, or a total of more than a thousand valves. A defect in a single one of these would have been disclosed by the tests which were made.

Capacity.—During the eight-hour test, the lowest rate of speed for any five-minute interval was 17.6 revolutions per minute, the highest was 23.4 revolutions per minute, and the average speed for the whole eight hours was 21.46 revolutions per minute. This speed gives the pump a capacity of 20.6 million gallons per 24 hours.

Friction.—The difference between the work done by the steam on the pistons and that delivered by the plungers is the work absorbed by the engine in the form of friction. The data show that but 4.6% of the indicated power was lost in this way. This is unprecedentedly small. It is altogether probable that a more elaborate test, in which special attention is given to the indicator work, may change this figure, since the relation is such that a change of 1% in the indicated power would produce a change of 20% in the value of engine friction. For the present, however, the figure given represents the best information that is to be had, and there is nothing in the data to discredit it.

Steam Consumption per Horse-Power per Hour.—The performance of steam engines is often expressed in terms of the weight of dry steam required per horse-power per hour. A determination upon this basis for the engine tested gives a consumption of 11.26 lbs. This, so far as the undersigned knows, is less than is required by any engine the results of which have ever been reported. It is evident, therefore, that the engine excels both in the domain of hydraulic engineering and in that of steam engineering as well. [11.2 lbs. has been reported for the Chestnut Hill engine.—Ed. Eng. News.]

Conclusion.—The preceding paragraphs prove the engine tested to be a very unusual one, and that a definite determination of its performance will demand unusual skill and care. The test herein described was undertaken upon

the supposition that the engine could be tested by methods usually employed in such work, and that its performance would fall within the range of ordinary results. It has been advanced by careful, painstaking and conservative methods, and it is believed that the facts disclosed may be accepted with as much confidence as those ordinarily resulting from such work. It appears, however, that these facts tell a story so unusual as to give rise to a question concerning their accuracy. It goes without saying that processes which would stand unquestioned when they lead to commonplace results are carefully scrutinized when they point to an exceptional result.

The undersigned is not disposed to question unduly or to discredit in the least degree the material facts which are herein presented, but, for reasons stated, he would earnestly recommend that they be looked upon as tentative until they can be verified by a test conducted on a broader plan. What is needed is an array of data so elaborate that the action of every part of the machine may be completely analyzed, so that the facts as stated can be reinforced by evidences of such a character that it cannot be questioned. I hope, therefore, that your company may see its way clear to undertake at an early date an investigation which will comport with the high efficiency which will be disclosed by it.

The results obtained in the test are condensed as follows from Prof. Goss's report:

Cylinder diams., ins.; h. p., 29; int., 52; l. p.	80.
Pump plunger diameter, ins.	33.
Stroke of all pistons and plungers, ins.	60.
Duration of test, hours	8.
Revs. per min.	21.46
Steam pressure at engine, gage, lbs.	155.6
Barometric pressure lbs.	14.3
Temperature of water pumped, deg. F.	56.5
Temp. of discharge from condenser, deg. F.	79.5
Temperature of discharge from hot well, assumed as temperature of feed, deg. F.	111.7
Observed weight of water that passed weighing barrels, lbs.	68,648.
Weight of water discharged from hot well, assuming that 3% was vaporized, before reaching weighing barrels.	70,771.
Weight of water that leaked through condenser during test. To be subtracted, lbs.	60.
Moist steam used by engine, lbs.	70,711.
Moisture in steam, %	1.2
Dry steam used by engine, lbs.	69,802.
Water pressure against which pumps delivered, lbs.	80.
Total pressure against which pumps were operated, suction lift included, lbs.	88.7
Total HP. delivered by pumps	740.
Water shown by leakage test to have leaked by plungers and valves during test, lbs.	31.4
Horse-Power, by Indicator:	
h. p. cyl., head-end	143.5
h. p. cyl., crank-end	132.1
int. p. cyl., head-end	125.5
int. p. cyl., crank-end	121.2
l. p. cyl., head-end	129.9
l. p. cyl., crank-end	125.3
Total	775.5
Dry steam per I. HP. per hour, lbs.	11.26
Total heat in 1 lb. steam, at a gage pressure of 155.6 lbs. and containing 1.2 % of water, B. T. U.	1,184.1
Heat in 1 lb. water at temperature of hot well, 111.7° F., B. T. U.	79.7
Heat taken from each lb. of steam, B. T. U.	1,104.4
Heat consumed by engine, B. T. U.	78,033,000.
Results:	
Duty per 1,000 lbs. of dry steam used, as defined by contract, ft. lbs.	167,800,000.
Duty per million B. T. U., ft. lbs.	150,100,000.
Capacity per 24 hours, gallons.	20,000,000.

Notes Concerning Methods Used in Test.

Duration of Test.—As the test did not involve measurements at the boiler, 8 hours were considerd a sufficiently long period to give results possessing a high degree of accuracy.

Temperature of discharge from condenser is the average of readings, taken at 10-minute intervals, from a thermometer placed in the pipe between condenser and air pump.

Temperature of discharge from hot well is the average of readings, taken at 10-minute intervals, from a thermometer placed in the hot well. The increase in temperature of the hot well over that of the condenser is due to the discharge of hotter water from the jackets into the hot well.

Water from the hot well is, under normal conditions, led to a feed pump attached to the plunger of the low pressure engine, which forces it back to the boiler. For purposes of the test the feed pump was disconnected and its supply pipe blanked so that no water could pass it. It was assumed, however, in calculations incident to the test, that the temperature of the water delivered from the hot well was the temperature of the feed.

It has previously been noted that all water leaving the hot well is assumed to represent steam used by the engine. It came from three general sources, namely: From within the cylinders, from the jacket of the cylinders and the coils of the intermediate receivers, and from the drainage pockets between the cylinders. No effort was made to separate the steam from these several sources. There were no drains or pipes leading steam or water away from the engine which were not connected with the hot well.

The hot well is, however, provided with an overflow and a suction pipe leading to the boiler feed pump, but, as already noted, these were blanked in anticipation of the test. A small vent pipe leading from the top of the hot well was not blanked, but it was observed during the test that nothing escaped from its outer end.

Again, there was a small cold water pipe, the exhaust of a cellar pump and the exhaust of an air pump connected with the hot well; but, for purposes of the test, joints were broken except in the case of that of the air pump, which machine was not used during the test.

It is thought that these precautions were sufficient to ensure the delivery of all steam, chargeable to the engine, to the weighing barrels placed beneath the hot well.

Finally, the scales upon which the weighings were made were calibrated with 50-lb. standard weights and found to balance perfectly. There seems, in fact, to have been no possible chance for error in the observed weight of steam used by the engine, unless there was vaporization of water as it passed from the hot well to the weighing barrels, or a leak through the condenser. The extent of errors arising from these sources is next considered.

Weight of Water Discharged from Hot Well, Assuming that 3% was Vaporized Before Reaching the Weighing Barrels.—Any loss of water between the hot well and weighing barrels would apparently improve the performance of the engine. That there was some loss by vaporization cannot be doubted, since a slight amount of steam was always to be observed about the barrels. As, however, the temperature of the water delivered was but 111° F., it was thought at the time of the test that the effect of such losses would be entirely negligible. A review of the data, however, indicates the probability of a measureable loss from this cause, and it has been decided to fix its value at 3%. It could not have been greater than this, and if less it will be safe to reserve the establishing of this fact for a later test. This conclusion has the effect of raising the observed weight of steam used by the engine (68,648 lbs.) to 70,771 lbs.

Weight of Water Leaking Through Condenser.—Any leakage of cooling water into the steam of the condenser would apparently impair the performance of the engine.

The water space of the condenser constitutes in effect a portion of the main suction pipe of the engine. Under the conditions of the test there is a difference of pressure tending to produce leakage of about 10 lbs. As a preliminary to the main test, a man-hole in the lower part on the steam side of the condenser was opened; a valve in the main suction outside of the condenser was closed; and a primer delivering water from the force main to the suction was opened by such an amount as would maintain a water pressure on the condenser of 10 lbs., thus producing for the purposes of a leakage determination the same difference of pressure which exists where the engine is under normal working conditions. The amount of leakage thus determined amounted to but 7.5 lbs. per hour, an amount which, while insignificant, has nevertheless been carried forward in the calculations as a correction, its value for the 8-hour test being 60 lbs. The results prove the condenser to be exceptionally tight.

Percentage of moisture in steam was determined by a calorimeter applied to the main steam pipe close to the throttle of the engine.

Leakage by Plunger and Valves.—The sum of the various leakage amount to but 31.4 cu. ft. for the whole test, or about 0.003% of the total volume pumped. It is evident that so small a leakage is entirely negligible, and it is so recorded under the head of results.

Results.—Duty as defined by contract is the number of foot pounds of work done "per 100 lbs. of coal, assuming an evaporation of 10 lbs. of water per pound of coal." This statement is indefinite, but for the purpose of this report is is assumed to be equivalent to the foot pounds of work done by the pumps per 1,000 lbs. of dry steam under the conditions of pressure prevailing during the test. That is, the duty as defined by the contract is assumed to be the area of plunger in square inches multiplied by total pressure against which engine was used multiplied by length of stroke in feet multiplied by total number of single strokes multiplied by 1,000, divided by pounds of dry steam used.

Duty on basis of a million B. T. U., as defined by the American Society of Mechanical Engineers in their Transactions (Vol. XII., p. 534), is area of plunger in square inches multiplied by total pressure against which pumps were used multiplied by length of stroke in feet multiplied by total number of single strokes multiplied by 1,000,000, divided by heat consumed by the engine.

A MINE EXPLOSION at Brownsville, Pa., on Sept. 23, entombed 70 men and killed 8. The accident is said to have resulted from a gas pocket which was opened by the loosening of a large block of coal and took fire from the open lamps. This was followed by a fire damp explosion. No general cave-in occurred and it is expected that the casualties will be limited to the number given.

A DUST EXPLOSION, followed by a fire, totally destroyed the Union Elevator, at Toledo, O., on Sept. 20. The explosion had not sufficient force to tear asunder the bins and shafts, constructed of heavy planking well bolted together, but it blew off the whole roof and blew out every window. According to the Toledo "Blade," of Sept. 21, the chief of the fire department had only a few days before called the attention of the superintendent of the elevator to the fact that the building was full of dust and was therefore in danger of a dust explosion, and was told that fans were then being put in to remove the dusty air, but the work was not finished when the explosion took place.

A SERIOUS DERAILMENT from a most unusual cause occurred at Wellingborough Station, on the Midland Ry. of England, Sept. 2, and resulted in the death of six persons and the injury of many others. The train was a through express, which runs past the station at 60 miles per hour. Just as it was due a light baggage truck on the platform rolled off onto the track, and the station attendants were unable to remove it before the train struck it. The moral of this accident, to American engineers, is that station platforms should never be made with a grade, save a very light inclination to shed water. The lesson to English engineers (but one which they will doubtless be blind to) is the value of the locomotive headlight and pilot as safety devices. Had the English locomotive been equipped with a headlight, the engineer would probably have seen the obstruction on the track in time to at least partially check his speed. A pilot on the locomotive would in nine cases out of ten have thrown the obstruction clear of the track.

THE CHANGE FROM STEAM TO ELECTRICITY on the Manhattan Elevated R. R. is likely to be made at an early date, according to public statements by President George Gould. It is also reported that two Chicago railways—the Illinois Central and the Chicago & Eastern Illinois—will adopt electricity for their suburban traffic. The same report has so often been circulated before that undue importance will hardly be attached to it now. It is probably true, however, that both these companies are continuing the careful investigations which they have long had in progress respecting the merits of electric traction. On the Brooklyn Elevated R. R., the matter of substituting electricity for steam is to be submitted to the Board of Directors at their next meeting.

THE READING RAILWAY SUBWAY, in Philadelphia, has been lately officially inspected by the Director of the Department of Public Works and other officials. This work was authorized in 1894, and construction was commenced, on Sept. 10 of that year, in the preliminary change in sewer location made necessary by the subway; which was completed in 1895, at a cost of $427,888. Work was commenced on the subway proper in August, 1895. The total work contemplated includes an elevated structure 950 ft. long; 4,180 ft. of open subway; a tunnel of 2,711 ft., and an open subway of 2,150 ft.; the total length of the work covering nearly two miles. At the present time most of the street bridges are open to traffic; the western half of the new freight houses, in the depressed yard at Broad St., and the track to operate them, are finished; work on the tunnel is rapidly progressing from the west end; in the open subway west of the tunnel the north retaining wall is finished and much of the excavation is done. The most difficult work called for was the underpinning of a number of great factory buildings alongside the subway; these included part of the Baldwin Locomotive Works, Wm. Sellars & Co., the Twentieth St. Grain Elevator, and other large establishments.

THE AMOUNT OF UNDERGROUND ELECTRIC CONduit in Washington, D. C., is, according to Mr. Walter C. Allen, Chief Electrical Engineer, D. C., 459,393 ft. of conduit, with 2,745,050 ft. of ducts used in carrying light, power and telegraph wires, distributed as follows:

	Conduit, ft.	Ducts, ft.
U. S. Electric Lighting Co.	229,194	825,755
Potomac Elec. Power Co.	56,129	508,144
Postal Telegraph Co.	14,963	18,944
Chesapeake & Potomac Telephone Co.	79,781	606,216
Metropolitan Railroad Co.	31 417	204,140
Capital Traction Co.	48,218	399,851
	459,393	2,745,050

A NEW INCANDESCENT FILAMENT for electric lights has been announced by Dr. Auer von Welsbach, the inventor of the incandescent gas light. He uses a filament of osmium, a rare metal, coated with a refractory oxide, like thoria. Osmium is found as an alloy of certain ores of platinum and iridium; it is a bluish-gray metal; 191.1 in atomic weight, and has the enormous specific gravity of 22.477, making it the heaviest substance known. It is practically infusible and resists temperatures in which platinum and iridium volatilize. It is well known that the intensity of light emitted by incandescent substances increases rapidly with their absolute temperature; hence, when osmium is heated in a vacuum by an electric current, strong enough to volatilize platinum, it emits a white light of agreeable color, but of great intensity. By coating the naked filament of osmium with the highly refractory oxide, it stands a greater temperature still. Economy in the production of electric light is the end sought by the use of this new metal; but osmium now costs $1.10 for 20 grains, hence the new light is likely to be only a scientific curiosity.

STREET RAILWAY STATISTICS of an interesting nature are given in the last issue of the American Street Railway Directory. From these it appears that there is a total of 1,074 street railways in the United States, made up of 909 electric, 21 cable, 31 steam and 113 horse lines. These have a total capital stock of $975,025,827, and are bonded for $527,970,220. The total track mileage amounts to 16,466.78, of which 14,673.71 is electric, 485.68 cable, 618.54 steam, and 688.85 horse. In their operation are required 48,209 cars, 32,606 of which are motor cars, 7,824 trailers, 2,920 cable, 1,887 steam, and 2,882 horse. In addition, there are 610 steam locomotives and 3,504 horses. The four leading street railway states are as follows:

	-No. roads.- Total.	Electric.	Stock.	Bonds.	—Cars.— Total.	Electric.	—Track miles.— Electric.	Total.
Pennsylvania	170	165	$234,960,000	$107,360,820	5,488	5,078	1,806	1,824
New York	120	88	198,857,600	105,901,100	10,201	5,337	1,600	2,102
Massachusetts	86	84	31,350,200	15,703,600	5,323	5,024	1,450	1,461
Illinois	55	51	119,053,000	64,210,900	4,401	2,107	1,024	1,138

ACETYLENE GAS FOR STREET LIGHTING is to be tried in Wabash, Ind. This is said to be the first attempt to use acetylene for this purpose.

THE DISCOVERY OF CHEMICAL ELEMENTS hitherto unknown has made great progress during the present year. No less than six have been reported, to which names have been given, as follows: Krypton, neon, metargon, coronium, polonium and etherion. The evidence that these new elements have been discovered is rather meager, as yet, and the existence of some of them may be open to doubt. The three elements first named were discovered by Prof. William Ramsay, of London, who, in 1895, in conjunction with Lord Rayleigh, had discovered argon. The three substances were all found with argon, after it had been isolated from liquid air. Taking the density of oxygen as 8, that of krypton is estimated at 40, that of neon at 10 or 11, and that of metargon, the same as argon, 20 or 22. The spectra of all these elements differ. Polonium is the name of an element not yet isolated, but which M. and Mme. Curie report to the French Academy of Sciences they have discovered in the form of a sulphide in pitchblende. The new element is said to resemble bismuth, chemically, and its radiating power is placed at 400 times that of uranium. M. Becquerel reported two years ago that salts of uranium threw off an invisible radiance much like that of the Rontgen rays, and a variety of pitchblende has been found by M. and Mme. Curie to possess that property to a much greater degree. Coronium is an element shown only, thus far, by the spectroscope, and only in the solar atmosphere. It has been found 300,000 miles from the sun's surface, and is believed to be much lighter than hydrogen. Etherion is the name given by Mr. Charles F. Brush, the well-known electrician, to an element which he thinks he has discovered in the atmosphere. He reported it at the recent meeting of the American Association for the Advancement of Science, in Boston. It is far lighter than hydrogen, and its heat conductivity is a hundred times as great as that of hydrogen. He estimates that its molecules vibrate with a velocity of a hundred miles a second, and thinks that it is not confined to the earth's atmosphere, but extends indefinitely out into space.

BISMUTH IN BRASS, even in minute percentages, is a cause of fire-cracks, according to a paper by Mr. Erwin S. Sperry, of Bridgeport, Conn., which will be presented at the meeting of the American Institute of Mining Engineers, at Buffalo, next month. As the result of a series of experiments on brasses containing various percentages of bismuth, Mr. Sperry reached the following conclusions:

1. Bismuth renders brass cold-short, and is similar in this respect to antimony, although the effect is not as marked.
2. Bismuth is a cause of fire-cracks in brass.
3. High brass intended for cold-rolling should not contain over 0.01% of bismuth.
4. Bismuth produces hot-shortness in brass.
5. Bismuth is a cause of latent fire-cracks in brass.

In the use of the term latent in connection with fire-cracks it is the author's belief that while annealing is the cause of their existence, they do not exist as cracks in the metal after annealing, but as lines of inferior cohesion in an apparently homogeneous mass; rolling, however, develops them, and to all appearances they then partake of every characteristic of true fire-cracks. It seems advisable, therefore, to apply such a distinguishing term, especially as latent fire-cracks are liable to be mistaken for rolling-cracks.

DRYING THE MOISTURE OUT OF IRON ORE at the mines is a new project which is reported to be under consideration by the Carnegie Steel Co. and the Oliver Mining Co., of Pittsburg. An article in the "Pittsburg Times" states that experiments have been made by Dr. N. P. Hulst, manager of the Oliver Mining Co., on drying the ores of the Mesaba range, which contain from 7.5 to nearly 14% moisture. It has been found that on an average 10% of water could be dried out. It is estimated that the saving in freight on the moisture in 3,000,000 tons of ore would amount to $700,000 per year. It is said that the ore will not reabsorb the moisture after it has been driven off. No plans have yet been prepared for carrying out the experiment on a large scale, and the difficulties of doing the work on a commercial scale, without too great cost for fuel and labor, are no doubt formidable.

TIN PLATE STATISTICS, compiled by the Bureau of Statistics, give some interesting figures relating to the production in the United States. Previous to 1891 tin plate was not produced to any considerable extent in the United States. On Oct. 1, 1890, a duty of 2.2 cts. per pound was imposed on tin plate, and the manufacture was commenced here. In the year ending June 30, 1892, 13,646,719 lbs. were produced; in the next year this rose to 99,816,202 lbs.; in 1894 it was 139,223,457 lbs.; in 1897 it was 446,982,063 lbs., and the estimate for 1898 is 640,000,000 lbs. The imports of tin into the United States in this period have fallen from 1,036,489,074 lbs. in 1891, which was much above the average, owing to anticipation of duty, to 171,662,345 in 1898. The former owners of one of the largest tin plate establishments in the world have sold their works at Swansea, Wales, and propose to establish a factory near Pittsburg, Pa. The value of the tin plate imported into the United States in 1889 was $21,222,653; while the value of the import of 1898 was only $3,309,148. The average price per pound has fallen from 2.9 cts. in 1889, and 3.5 cts. in 1891, to 2.2 cts. per lb. in 1898. The U. S. law permits a rebate of 99% on the duty paid on imported tin plate where the article manufactured from it is to be exported. This applies to coal oil cans for foreign trade, canned meats for export, etc.; and deducting the foreign tin plate re-exported in this way, the Bureau finds that only about 33,764,775 lbs. of foreign tin plate went into domestic consumption in the United States in 1898.

THE EXPORT OF U. S. MANUFACTURED GOODS increases rapidly, and the Bureau of Statistics says that the exports of this class in July last amounted to $25,983,115 and formed 36.47% of the total exports. No previous July has shown such a record, and in no month have manufactures shown so large a percentage of the total exports. As compared with July, 1888, the exports have doubled and the percentage nearly so. The steady gain in percentage of total exports, for manufactured goods, is shown as follows: July, 1890, 24.82%; same month, 1894, 28.10%; 1895, 31.38%; 1896, 32.80%; 1897, 33.78%, and in July, 1898, 36.47%. This gain extends to nearly all the important industrial interests in the country, and must be read in connection with the general enormous increase in total exports. The exports of agricultural implements, in July, 1898, were about 50% above the previous July; the gain for the same month in cars and carriages was over 33%; there was also a marked gain in cotton goods and copper products. The exports of iron and steel, for July, 1898, were $7,012,977, as compared with $4,918,107 in July, 1897.

A BOTANICAL EXPLORATION OF PORTO RICO will be undertaken by Dr. N. Z. Britton, Chief Director of the New York Botanical Garden, and Mr. Cornelius Vanderbilt will bear the cost of the expedition, which is to study and bring back specimens of the flora of the island. Dr. Britton will probably start in November next, at the close of the rainy season. There is very little known of the flora of this island, and the results will much enrich the general knowledge of the natural resources of Porto Rico.

ROAD-BUILDING IN PORTO RICO, says Gen. Roy Stone, is easy and inexpensive; but the whole future of the island depends on the development of internal means of communication. Gen. Stone in six days converted into a road fit for army wagons a goat-path hugging the steep hills lying between Adjuntas and Utuado, ten miles apart. In this section there is an abundance of rotten granite which yields readily to the pick and shovel and forms an excellent road material. There is no frost to interfere with road construction, and Gen. Stone estimates that roads could be built almost anywhere in the island for from $750 to $1,000 per mile with native labor, which is satisfied with 20 cts. per day in American money. A marginal railway, about 300 miles long, will probably soon skirt the island, as 150 miles of this is now in operation between certain coast towns. The military engineering staff in Porto Rico is now investigating harbors, possible railway routes and centers, and are locating roads, and building some of the latter. Two mountain ranges extend through the entire length of the island and interior railways may be difficult and expensive to build; but owing to the density of the population electric roads could be profitably built to connect the interior and the coast towns.

THE VOLUNTEER SIGNAL CORPS, under charge of Gen. Greely, has done good work in Cuba and Porto Rico, according to that officer's report. It destroyed submarine cables under fire from the enemy, and repaired cables useful to our forces; and it arranged and maintained a system of cable and land lines that enabled messages to be sent in 20 minutes from army lines near Santiago to Washington. In Porto Rico it was always in the advance, and kept each important command in telegraphic or telephonic communication with corps headquarters and the base of operations; the same was true in the army operations before Manila, and this corps connected by cables the principal forts in our great harbors and initiated and installed an entirely new electrical fire control system at these forts.

NEW ATLANTIC STEAMSHIP ROUTES, to avoid the dangers of the Grand Banks off Newfoundland, are proposed by Capt. W. H. Smith, the Canadian Wreck Commissioner. The present routes are subject to fog in this region from May to August, inclusive, just when travel is heaviest. Capt. Smith suggests that steamers leaving this coast in the summer months shall sail due East on the parallel of 40° North, until they reach longitude 47° West, and thence sail on a great circle track to the point of destination. This route is safe from fog, but longer than the present routes nearer to the pole. Short passages save coal, and good time records advertise the company; consequently, nothing but a general agreement among steamship companies to use the new route, or the passage of laws punishing captains who meet with an accident by reason of being outside of prescribed routes, can turn the line of travel further south.

A MEMORIAL TO GEN. RUFUS PUTNAM, one of the principal engineers of the Revolutionary Army, has been placed upon the old Putnam house at Rutland, Mass., by the Massachusetts Society of the Sons of the Revolution. Gen. Putnam, who must not be confused with Gen. Israel Putnam, was the engineer who planned the works which compelled the British to evacuate Boston and the fortifications at West Point. He also organized and assisted in carrying out the scheme of the Ohio Company, which, in 1788, commenced the settlement of the Northwest Territory. U. S. Senator George F. Hoar, in his dedication address, remarked that Washington classed Putnam as "the best engineer in the army, whether French or American." A bronze tablet, setting forth the services of Gen. Putnam, was placed upon the old house where he lived from 1781 to 1788, and in which he planned and matured the scheme that prevented slave holding in the great West and opened up that country to settlement. Gen. Putnam was born in Sutton, Mass., in 1738, and was a millwright by trade; he served in the French and Indian War in 1757-60, and later obtained a good knowledge of mathematics and surveying, and, in 1773, he was Deputy Surveyor of the Province of Florida. At the beginning of the Revolution he was a lieutenant-colonel of a regiment, and later commanded a regiment in Gen. Wayne's brigade. At the close of the Revolution he was made a brevet Brigadier General. He formed the Ohio Company and founded the town of Marietta. He died at Marietta in 1824.

BOOK REVIEWS.

MANUAL OF TOPOGRAPHIC METHODS.—Published by the U. S. Geological Survey. Sheep and paper; pp. 340; 18 plates. Sheep, $2.15; paper, 65 cts.

This excellent manual upon the government methods of making topographical surveys is again listed among the publications for sale by the Superintendent of Documents, at Washington, D. C. Remittance should be made by postal money-order payable, in this case, to the Director of the U. S. Geological Survey.

LIGHTING BY ACETYLENE. — Generators, Burners and Electric Furnaces. By William E. Gibbs, M. E. New York: D. Van Nostrand Co. 12mo.; cloth; pp. 141; 66 illustrations. $1.50.

The literature of acetylene has grown to vast proportions in the form of patent specifications, articles in the newspapers, etc., but the book before us is, as far as we know, the first book in the English language upon the subject. The author's reason for writing it appears in the following extract from the introduction:

A recent serious explosion of liquid acetylene prompts the writing of what follows, since it would seem that ignorance or neglect of the admonitions of earlier experimenters was to blame for an accident which cannot but prejudice many against the use of a valuable and safe illuminant.

The book is an ably written, brief and plain treatise on acetylene, its history and its dangers, and on electric furnaces for the generation of carbide of calcium acetylene gas generators and lamps. In regard to the explosiveness of acetylene the author holds that at atmospheric pressure it is no more dangerous than any other illuminating gas. While it is under certain conditions an unstable body, tending to resolve itself into its component elements, carbon and hydrogen, yet this dissociation can be effected at atmospheric pressure only by the detonation in the body of the gas of a small quantity of fulminate of mercury or other violent explosive "and by no other means." The author here seems to neglect the rule of logic that a negative cannot be proven, but he comes as near to attempting a proof as is possible in his next sentence:

Heat, flame, the electric spark, or the electric arc itself will not, according to the most careful experiments, produce an explosion under these conditions.

Of course a mixture of air with acetylene is highly explosive, as is a mixture of air with any other hydrocarbon gas. The pure gas itself if condensed to a high pressure is also explosive, and the author says that it becomes more unstable with each increment of pressure,

and in consequence more easily exploded, until the point of liquification is reached, when it becomes as dangerous as the high explosives. The disastrous results which have invariably followed the attempts to liquify acetylene on a commercial scale should be sufficient warning against this procedure. The only place where there is any excuse for compressing acetylene is in the chemical laboratory, where its properties are being studied by those dealing in unstable compounds, and where explosions are expected and provided for as a matter of course.

Another danger consequent upon the use of acetylene is the formation of the explosive salt, acetylide of copper. The use of copper and copper alloys should therefore be avoided in acetylene generators or holders.

The book contains the rules of the New York Board of Fire Underwriters for the installation of acetylene gas generators and for the storage of calcium carbide, and a list of United States patents on calcium carbide and acetylene apparatus, including carbide and electric furnaces. It describes a great variety of generators for making the gas from carbide of calcium, and of lamps and burners. We commend the book to all who desire to inform themselves on actylene, its generation and use.